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August 10, 2018

VIA HAND DELIVERY

Mr. Joel H. Peck, Clerk
c/o Document Control Center
State Corporation Commission
Tyler Building – First Floor
1300 East Main Street
Richmond, Virginia 23219

RE: Virginia Electric and Power Company – Integrated Resource Plan filing for 2018 pursuant to Va. Code § 56-597 et seq.

Case No. PUR-2018-00065

Dear Mr. Peck:

Attached for filing in the above-referenced matter is the Direct Testimony and exhibits of James Wilson on behalf of Appalachian Voices ("Environmental Respondents"). Pursuant to 5 VAC 5-20-150 of the Commission's Rules of Practice and Procedure, this filing is being completed by hand delivery.

If you should have any questions regarding this filing, please do not hesitate to contact me at (434) 977-4090.

Regards,

William C. Cleveland

cc: Parties on Service List
Commission Staff

COMMONWEALTH OF VIRGINIA
STATE COPORATION COMMISSION

APPLICATION OF VIRGINIA ELECTRIC AND POWER COMPANY	)	Case No. PUR-2018-00065
In Reference Virginia Electric and Power Company's Integrated Resource Plan filing pursuant to Va. Code § 56-597 et seq.	)	

SUMMARY OF

DIRECT TESTIMONY OF

JAMES F. WILSON

ON BEHALF OF

ENVIRONMENTAL RESPONDENTS

August 10, 2018

Summary of the Testimony of James F. Wilson

My testimony evaluates the Company's peak load forecast and the calculation of the Total Resource Requirements used in the 2018 Plan, and provides recommendations.

I conclude that due to flawed and outdated forecasting methodology, the Company has significantly overstated its future electricity peak load. The Company's peak loads have been flat for a decade now; for all customers other than data centers, the peak loads are actually declining. Despite this well-established trend, the Company persists in forecasting 10% peak load growth over the first six years of the Plan, mainly due to the thirty-year historical period used for the forecasting. The Company also overstates the portion of the Dominion Zone peak load that it will serve, ignoring that the peak loads of other load-serving entities in the Dominion Zone (in particular, Northern Virginia Electric Cooperative) are growing at a faster rate.

I also conclude that the Company's separate data center forecast is not supported by evidence and is speculative. While in recent years the Company has commissioned studies to forecast data center loads, this year it simply fit an S-shaped curve ("Bass Diffusion Model") to historical data and used that as its forecast. This is a completely arbitrary approach. Better-fitting curves suggest much slower growth, and the Company also failed to recognize that loads at existing data centers are shrinking due to efficiency improvements.

Importantly, the Company has not evaluated or implemented any enhancements to its load forecasting methodology, despite the chronic over-forecasting for over a decade. I conclude that PJM's forecast, which predicts much less load growth in Dominion's service territory, while still conservative and likely too high, is likely far more accurate than the Company's.

Finally, I offer specific recommendations for the Commission to consider in future plans that should improve the Company's peak load forecasting.

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CONTENTS

I. INTRODUCTION AND QUALIFICATIONS

Q 1: Please state your name, position and business address.

A: My name is James F. Wilson. I am an economist and independent consultant doing business as Wilson Energy Economics. My business address is 4800 Hampden Lane Suite 200, Bethesda, Maryland 20814.

Q 2: On whose behalf are you testifying in this proceeding?

A: I am testifying on behalf of the Environmental Respondents: Appalachian Voices.

Q 3: Please describe your experience and qualifications.

A: I have thirty-five years of consulting experience, primarily in the electric power and natural gas industries. Many of my assignments have pertained to the economic and policy issues arising from the interplay of competition and regulation in these industries, including restructuring policies, market design, market analysis and market power. Other recent engagements have involved resource adequacy and capacity markets, contract litigation and damages, forecasting and market evaluation, pipeline rate cases and evaluating allegations of market manipulation. I also spent five years in Russia in the early 1990s advising on the reform, restructuring, and development of the Russian electricity and natural gas industries for the World Bank and other clients.

With respect to the load forecasting and capacity requirements issues I will address in this testimony, I have been actively involved in these issues in the PJM Interconnection, L.L.C. ("PJM") region for many years, participating in PJM stakeholder processes, performing and presenting analysis of these issues, and submitting affidavits in various regulatory proceedings.

I have submitted affidavits and presented testimony in proceedings of the FERC, state regulatory agencies, and U.S. district court. I hold a B.A. in Mathematics from Oberlin

College and an M.S. in Engineering-Economic Systems from Stanford University. My curriculum vitae, summarizing my experience and listing past testimony, is attached as Attachment JFW-1.

Q 4: Have you previously submitted testimony in Virginia State Corporation Commission ("Commission") proceedings?

A: Yes. I submitted direct testimony on behalf of Environmental Respondents in Case No. PUE-2017-00051 last year (Virginia Electric and Power Company's 2017 Integrated Resource Plan) and in Case No. PUE-2016-00049 the prior year (Virginia Electric and Power Company's 2016 Integrated Resource Plan). I also submitted direct testimony on behalf of Commission staff in Case No. PUE-2009-00043 in 2009 (Application of PATH Allegheny Virginia Transmission Corporation for Certificates of Public Convenience and Necessity).

Q 5: What is the scope and purpose of your testimony in this case?

A: This proceeding involves the 2018 Integrated Resource Plan ("2018 Plan") for Virginia Electric and Power Company ("Dominion" or the "Company"). My assignment was to evaluate the forecasts of peak loads and Total Resource Requirements included in the 2018 Plan and provide any recommendations.

II. SUMMARY AND RECOMMENDATIONS

Q 6: How are the Company's forecasts of peak loads and Total Resource Requirements from the 2018 Plan used?

A: The Total Resource Requirements ("TRR") are the Company's estimates of the amount of capacity that will be assigned to the Company by PJM for purposes of allocating capacity costs. The TRRs are calculated as the forecast peak load for the Dominion Load-Serving Entity ("DOM LSE") plus a reserve margin. As such, the TRRs represent

the Company's estimates of its customers' future generating capacity needs, and the 2018 Plan describes how the Company plans to meet these needs through owned and contracted resources.

The Company also relies upon the load forecasts prepared for its Integrated Resource Plans in other proceedings. For example, Glenn A. Kelly, Director of Generation System Planning, relied upon the load forecast prepared for the Company's 2015 Integrated Resource Plan in testimony supporting the Company's application for certificates of public convenience and necessity to construct a 1,588 megawatt natural gas-fired combined-cycle generation facility in Greensville County, Virginia. In that testimony, Mr. Kelly noted that "[n]o party contested the Company's load projections supporting the need for the Project in the 2015 Plan proceeding."[1]

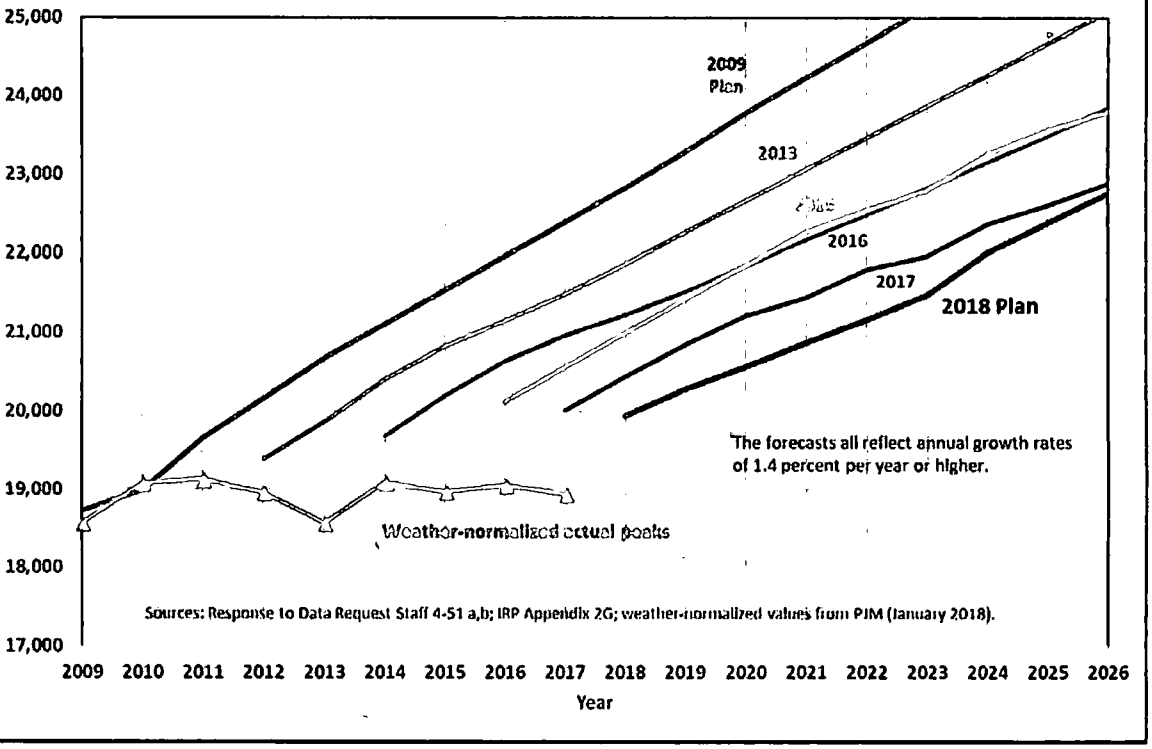
Q 7: Please summarize how the Company determines the load forecasts and TRRs.

A: The Company's approach entails the following steps.

1. Forecast the Dominion transmission zone ("DOM Zone") future peak loads (adding in a separate forecast of data center peak loads);
2. Estimate the DOM LSE portion of the DOM Zone peak loads;
3. Determine the reserve margins needed above and beyond the DOM LSE peak loads;
4. Sum the peak loads and reserve margins to determine the TRRs.

[1] Rebuttal Testimony of Glenn A. Kelly filed December 18, 2015 in Case No. PUR-2015-00075, pp. 2-3.

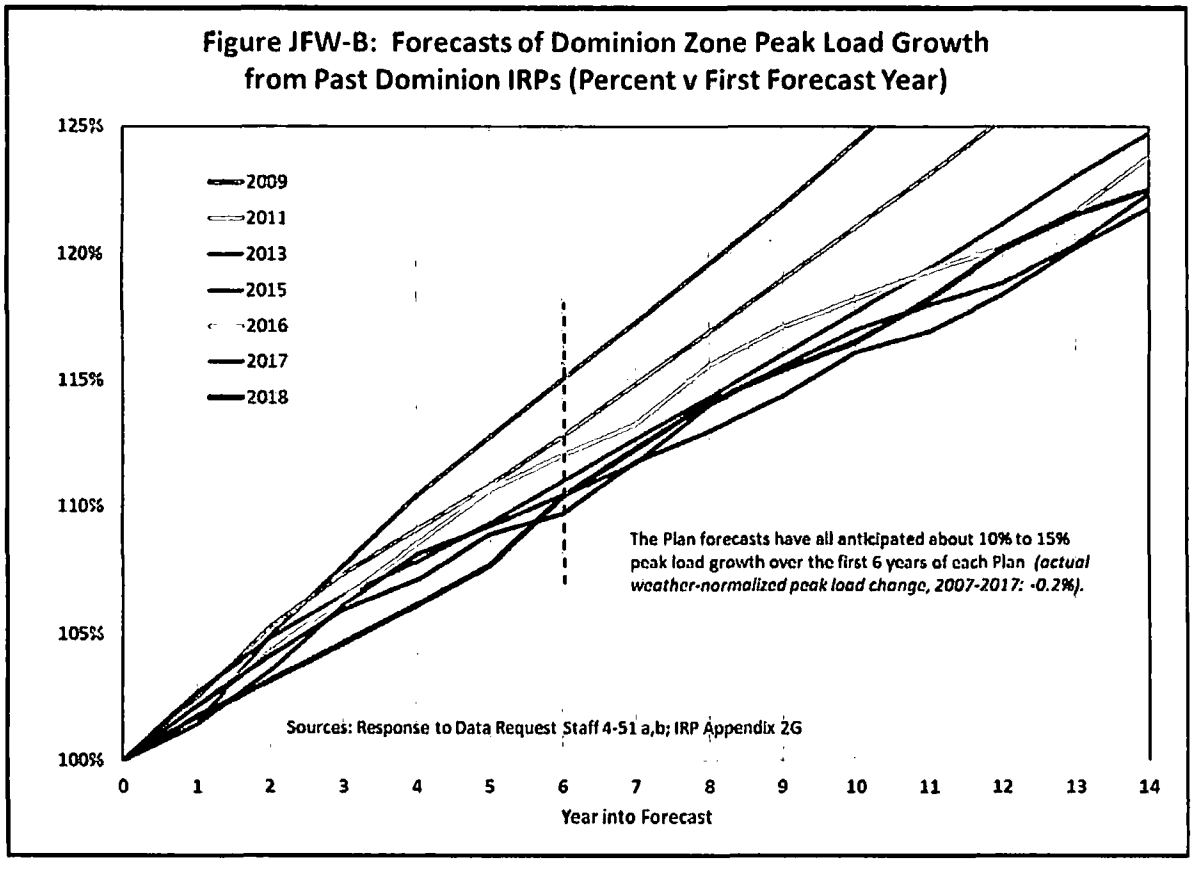
Figure JFW-A: Forecasts of Dominion Zone Summer Peak Load Growth from Past Dominion IRPs



Q 8: Please summarize your evaluation and conclusion regarding the Company's DOM Zone peak load forecasts used in recent integrated resource plans.

A: While peak loads in the DOM Zone (on a weather-normalized basis) have been flat over the past decade, year after year the Company persists in forecasting peak load growth well in excess of one percent per year, as shown in Figure JFW-A.

The forecasts for all of the Plans from 2009 through 2018 have anticipated 10% to 15% growth over the first six years of each plan, as shown in Figure JFW-B, while actual peak load growth over the past decade has been nil. The inaccuracy of the Company's peak load forecasting has resulted in repeatedly over-stating future capacity needs (TRRs) by thousands of MW.



Q 9: Please comment on the Company's forecast of data center peak loads.

A: The Company adjusts its econometric DOM Zone peak load forecasts upward based on separate forecasts of data center peak loads. In the past the Company commissioned studies by Quanta Technology to form the basis for these forecasts. However, the last Quanta Technology study and forecast was prepared in 2015. The Company did not rely on that study nor did it commission a new study. At this time the Company has no research or analysis to support its forecast of data center loads,[2] and apparently is not in possession of firm evidence of new data center loads in 2019 or later years.[3]

Instead, the Company's new data center forecast results from fitting an S-shaped curve to the historical data. As I will discuss in detail, this is a highly unreliable and arbitrary approach that can be applied to produce just about any desired forecast.

At the same time, the Company provides data suggesting that the loads at existing data centers are shrinking about ten percent per year due to efficiency improvements. Thus, even if new data center capacity is added at a rate of ten percent per year, the total data center load could remain flat due to efficiency improvements.

I conclude that the Company's data center forecast is not supported by firm evidence or market studies and is highly speculative; while there likely will be additional new data centers, it is also likely that the loads of existing data centers will continue to shrink. In addition, the Company has apparently not incorporated its separate data center forecast into its overall forecast correctly, taking into account the embedded amount. The Commission should focus on the peak load forecast for all other customers, and consider the future changes in data center load highly uncertain.

Q 10: Please summarize your comparison of the Company's forecasting to PJM's.

A: PJM produces a superior (if still too high) forecast for the Dominion Zone based on a superior methodology. PJM's forecast is lower by over 1,000 MW for 2021, and over 1,700 MW by 2024, as shown in Table 1 below.

Q 11: The 2018 Plan acknowledges that the Company's DOM Zone forecast remains well above PJM's, but claims that this reflects methodological differences that were explained in Section 2.3 of the 2017 Plan. Please comment.

A: I evaluated these claims in detail in my testimony last year in regard to the 2017 Plan.[4] I concluded that none of the Company's criticisms or proposed changes is warranted or would improve PJM's forecast. In addition, some of the Company's "adjustments" were

[4] Direct Testimony of James F. Wilson on Behalf of Environmental Respondents, filed August 11, 2017 in Case No. PUR-2017-00051, pp. 43-52.

calculated incorrectly. The Company provided no updated narrative discussing the differences, and provided no updated or corrected workpapers for the alleged differences.[5] My conclusion that the Company's forecast is far too high, and PJM's forecast is likely to be more accurate than the Company's, is unchanged by these incorrect claims.

Q 12: Has the Company evaluated and implemented any enhancements to its load forecasting methodology, in light of the poor recent performance?

A: No; and this should perhaps be of greatest concern to the Commission. The Company states that over the past twenty years it has made no changes to its methodology, only to the data used.[6] The Company does not systematically conduct accuracy analyses and could not provide any documents pertaining to the accuracy of its forecasts. In particular, the Company has not even evaluated using a shorter historical period than the thirty years it has been using, a change that would allow the recent trends to have more influence on the forecasts.[7] Nor does the Company perform any sensitivity analysis around its forecasting.[8] The Company is apparently unconcerned about the chronic inaccuracy, and lacking in curiosity about why its forecasts are inaccurate and how they could be improved.

In contrast to the Company's inaction, PJM staff are continually evaluating and designing potential enhancements to their load forecasting methodology. They apply their methodology to forecast over twenty zones, and frequently evaluate the performance of

[5] Responses to Data Requests ER 6-6 and ER 1-30.
[6] Response to Data Request ER 1-7.
[7] Response to Data Request ER 1-12.
[8] Response to Data Request ER 1-27.

their forecasts. In these efforts, PJM staff benefit from suggestions and reactions from approximately fifty load forecasters and other experts participating in the PJM Load Analysis Subcommittee, who represent the diverse regions of the PJM footprint.

Q 13: Please summarize your evaluation and conclusion regarding the Company's forecast of the peak loads for the DOM LSE.

A: While the Company has overstated DOM Zone peak loads, the Company has also overstated the likely DOM LSE portion of current and future DOM Zone peak loads, as a result of using a simple historical average to determine the DOM LSE portion. This is inaccurate because peak loads are growing faster elsewhere in the DOM Zone. In particular, the Company's approach fails to recognize that the one major source of peak load growth – data centers – is largely occurring in areas served by other DOM Zone LSEs (notably, Northern Virginia Electric Cooperative, or NOVEC), a fact that is difficult to discern from the 2018 Plan and the Company's responses to data requests. I have used a conservative approach to estimating the DOM LSE portion of the zonal peaks, based on the Company's data and approach, but recognizing the faster growth of other LSEs in the DOM Zone.

Q 14: Please summarize your conclusions with respect to the Company's reserve margin and TRR calculations.

A: The Company attempts to follow PJM's approach for its reserve margin and total resource requirement calculations, but the Company's approach is different, and some of the values used were not accurate. However, the results (as a percentage of peak load) are similar, so I used the Company's effective reserve margin for my TRR calculations for all years.

Q 15: Please present your revised peak load forecasts and TRR values.

A: Table 1 presents the results. It reflects PJM's latest forecast for the DOM Zone, a revised estimate of the DOM LSE peaks as a portion of DOM Zone peaks, and TRRs based on the effective reserve margin applied to the revised DOM LSE peaks.

PJM's DOM Zone forecast is still too high, for the same reason the Company's is too high – use of a long historical period results in a forecast that fails to recognize the well-established recent trend of flat or declining loads. Thus, all of the values in Table 1 are likely to be too high, with the PJM-based numbers likely to be high and the Company's numbers far too high.

My conservative estimate of the DOM LSE adjusted peak load is 828 MW lower than the Company's forecast by 2020, over 1,100 MW lower by 2022, and over 2,000 MW by 2026. My conservative estimates of the Company's TRRs are over 1,000 MW lower for 2021, and over 2,000 MW lower by 2025.

Table 1 also shows, for reference, the TRRs associated with the loads for all customers other than the data centers. Note that the capacity need to meet these loads is roughly the same in 2025 as for 2019, under the revised forecast based on PJM.

Table 1: Peak Load Forecast and Total Resource Requirements (MW)

	2019	2020	2021	2022	2023	2024	2025	2026
DOM Zone Peak Load Forecast								
2018 Plan	20,282	20,568	20,867	21,161	21,477	22,010	22,381	22,757
Based on PJM [1]	19,695	19,703	19,816	20,010	20,113	20,247	20,404	20,546
Difference	*-587*	*-865*	*-1,051*	*-1,151*	*-1,364*	*-1,763*	*-1,977*	*-2,211*
DOM LSE Adjusted Peak Load Forecast								
2018 Plan	17,674	17,766	18,026	18,284	18,559	19,025	19,351	19,682
Revised [2]	17,103	16,938	17,024	17,181	17,256	17,353	17,477	17,587
Difference	*-571*	*-828*	*-1,002*	*-1,103*	*-1,303*	*-1,672*	*-1,874*	*-2,095*
DOM LSE Total Resource Requirement								
2018 Plan	19,773	19,869	20,144	20,431	20,738	21,259	21,624	21,993
Revised [2]	19,134	18,944	19,024	19,198	19,281	19,390	19,529	19,652
Difference	*-639*	*-925*	*-1,120*	*-1,233*	*-1,457*	*-1,869*	*-2,095*	*-2,341*
DOM LSE Total Resource Requirement, for All Loads Other Than Data Centers								
2018 Plan	18,702	18,654	18,781	18,919	19,083	19,469	19,712	19,974
Revised [2]	17,945	17,650	17,606	17,694	17,749	17,859	17,999	18,124
Difference	*-757*	*-1,004*	*-1,175*	*-1,226*	*-1,334*	*-1,610*	*-1,713*	*-1,850*

[1] Based on PJM July 2018 forecast update.

[2] Based on PJM July 2018 forecast and revised DOM LSE percentages.

Q 16: Do you have recommendations with regard to peak load forecasting and TRR calculations for the purposes of future Integrated Resource Plans?

A: Yes I do. I recommend that the Commission consider requiring the following of the Company, for future plans:

1. To present recent weather-normalized peak loads for the DOM Zone and/or DOM LSE (either prepared by the Company, or by PJM), and to discuss recent trends in weather-normalized peak loads.

2. To commission a forecast of data center loads by an outside firm (as the Company did in 2013 and 2015, resulting in the reports and forecasts prepared by Quanta Technology).

3. To fully separate the forecasting of data center peak loads from the forecasting of all other customer peak loads, and to present the history and forecast of data center and other loads separately.

4. To evaluate and report the estimated embedded amount of data center load reflected in the econometric forecasting, and to deduct this embedded amount from the exogenous data center forecast.

5. To provide an explicit forecast of the peak loads of the DOM LSE as a portion of the DOM Zone peak loads, taking into account data centers and any other sectors whose growth differs substantially for DOM LSE and other DOM Zone LSEs, with a discussion of recent trends in DOM LSE and Other LSE peak loads.

6. To present alternative load forecasts determined using 20- and 10-year historical estimation periods, in addition to the longer period currently used, and to provide a discussion of the differences and of the rationale for the choice of historical period.

7. To retain an outside consultant to perform a comprehensive review of the load forecasting methodology and make recommendations for improving its accuracy.

8. To determine the TRRs using PJM's approach to these calculations (using the PJM Forecast Pool Requirement and an estimate of the DOM LSE fleet-wide forced outage rate) for all years.

Q 17: How is the remainder of your testimony organized?

A: Section III reviews recent trends in peak loads in the DOM Zone, and presents the Company's and PJM's forecasts. Section IV discusses the data center forecasts and forecast adjustments. Section V addresses the forecast for DOM LSE as a portion of the DOM Zone forecast, and Section VI discusses the reserve margin and TRR calculations. Finally, Section VII provides conclusions and recommendations.

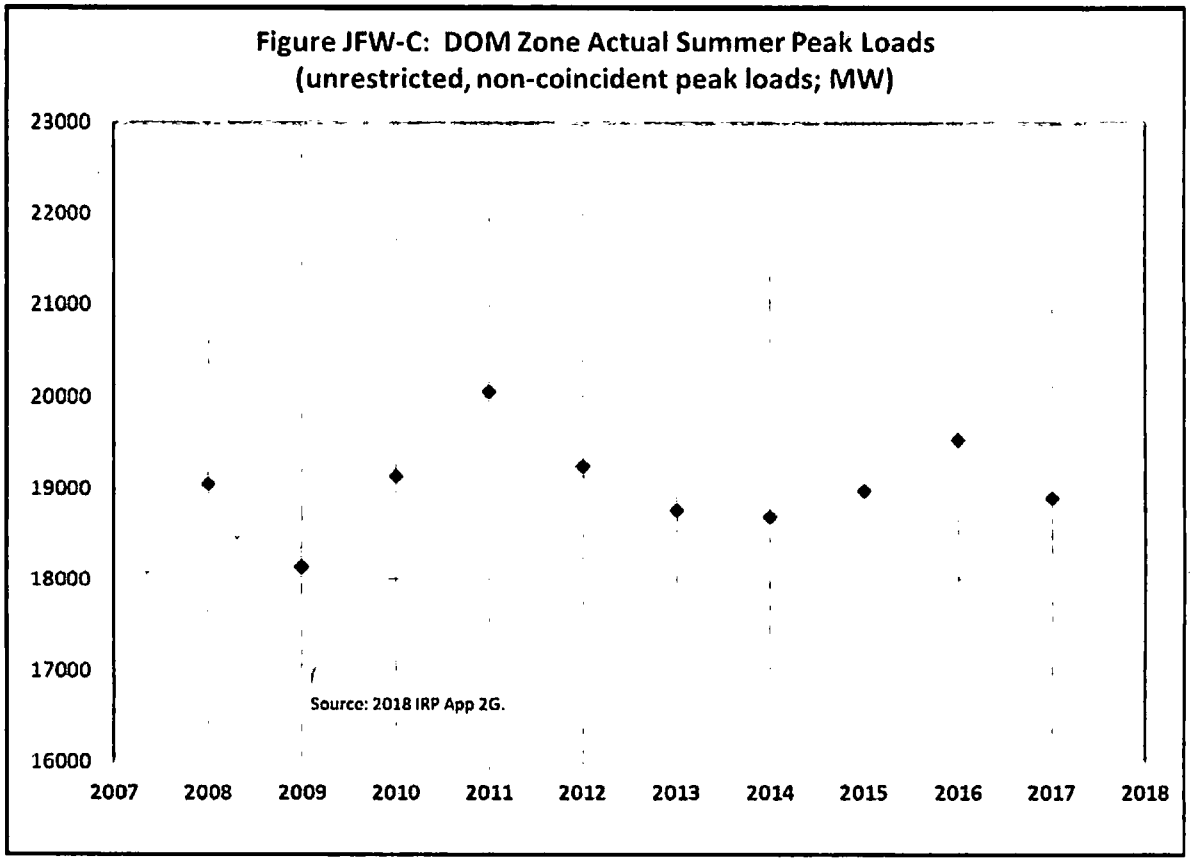
III. DOMINION ZONE PEAK LOAD TRENDS AND FORECASTS

Q 18: Please present the recent peak loads in the Dominion transmission zone.

A: Figure JFW-C presents the actual DOM Zone annual peak loads since 2007. These are the "unrestricted" peak loads, where any demand response or demand-side management by PJM or the Company that may have occurred during the peak hour has been added back.

Q 19: Please discuss any trend exhibited by these peak load values.

A: These actual peak loads do not suggest any clear trend over the past decade – for instance, the values for 2015 and 2017 are very similar to the values for 2008 and 2010. These actual peak loads reflect the actual weather that occurred each year, so they will tend to be high in years in which a very extreme period of hot or cold weather occurred, and they will tend to be low in years with only milder weather. Because actual peak loads reflect changeable weather, their pattern over relatively short periods of time may not reflect any trend, or may even be misleading, suggesting a trend that does not in fact exist.



Q 20: Is there a way to reveal the trends in past peak loads?

A: Yes. To discern the underlying trends in past energy loads, energy forecasters remove the weather impact by calculating "weather-normalized" historical values. For example, weather-normalized historical summer peak loads are estimates of what the summer peak loads would have been in past years had the weather, at the time of the summer peak load, been the typical (very hot) weather that tends to occur at the time of the summer peak load. This removes the year-to-year variability due to weather in the historical peak loads. With the year-to-year weather variability removed, the underlying, more stable trends in peak loads (due to forces such as economic and demographic growth, and changing electrical equipment stocks) are revealed.

Q 21: How do weather-normalized historical peak loads relate to forecast peak loads?

A: Weather-normalized historical peaks and forecast peaks essentially represent the same values. A forecast peak load is generally intended to be a median (or "50-50") peak; that is, the peak load level that has an equal chance of being exceeded, or not being exceeded, in the future year, depending upon weather and other uncertainties. The weather-normalized historical peak is generally the same concept – it is the peak load level in the historical year that had a 50-50 chance of being exceeded due to weather variability.

Put another way, the weather-normalized historical peak load is exactly the peak load that past and current peak load forecasting efforts attempt to determine. And, accordingly, we would expect that a peak load forecast would generally be consistent with the trend reflected in past weather-normalized peaks.

Q 22: Is it a standard industry practice to calculate weather-normalized values?

A: Yes. Energy forecasters consider historical weather-normalized loads extremely useful in understanding past trends and likely future trends, and it is a standard practice to prepare estimates of past energy loads on a weather-normalized basis. For example, the Company's witness Mr. Eric Fox of Itron testified in 2017 that weather-normalization can be a useful tool in the forecasting process, and that his company always normalizes electric and sales data, to evaluate historical trends.[9]

Q 23: How are weather-normalized peak loads calculated?

A: The approach usually entails modeling past energy demands, replacing the actual weather that occurred (which may have been unusually extreme, or unusually mild) with a

[9] Transcript of hearings in Case No. PUR-2017-00051, pp. 479-481.

"normal" weather pattern (including the usual magnitude and frequency of extreme weather), which may be an actual historical pattern or a synthetic one. There are many variations that can be used, and the various approaches will generally give similar results. A 2014 report by Itron, Inc. summarized weather normalization practices based on a survey to which energy forecasters from 135 companies across North America responded.[10]

Q 24: Does the Company prepare weather-normalized historical peak loads?

A: No. The Company provided weather-normalized energy sales, but states that "as a general practice, the Company does not weather normalize peak loads."[11]

Q 25: Are weather-normalized peak loads available for the DOM Zone?

A: Yes. PJM prepares weather-normalized historical peak loads for all of it zones.[12] PJM evaluates and revises its weather-normalization methodology from time to time, most recently in 2015.[13] This year PJM is considering further changes to its approach.[14]

Q 26: Please present and discuss the recent trends in weather-normalized peak loads for the DOM Zone.

A: Figure JFW-D presents PJM's weather-normalized historical peaks for the DOM Zone. The weather-normalized peak loads have been quite flat over the past decade. Even in

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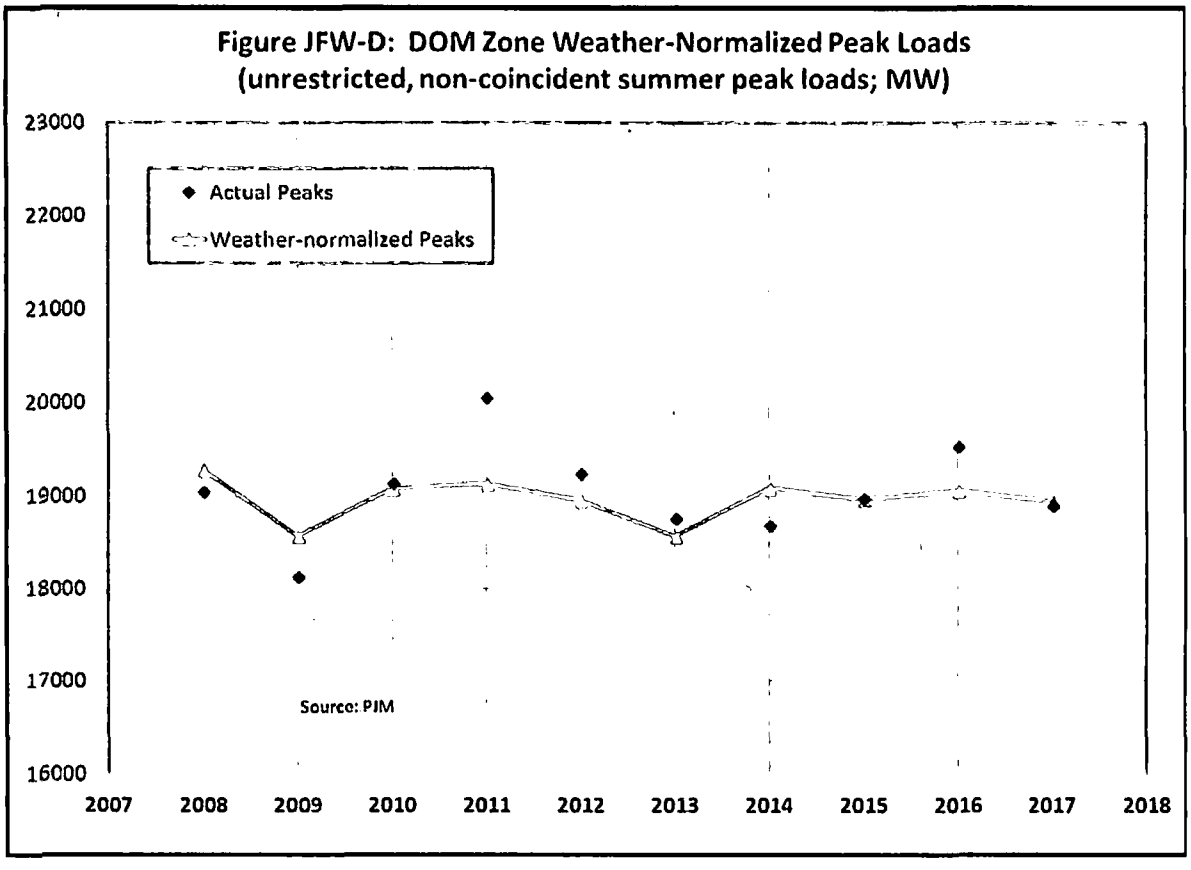
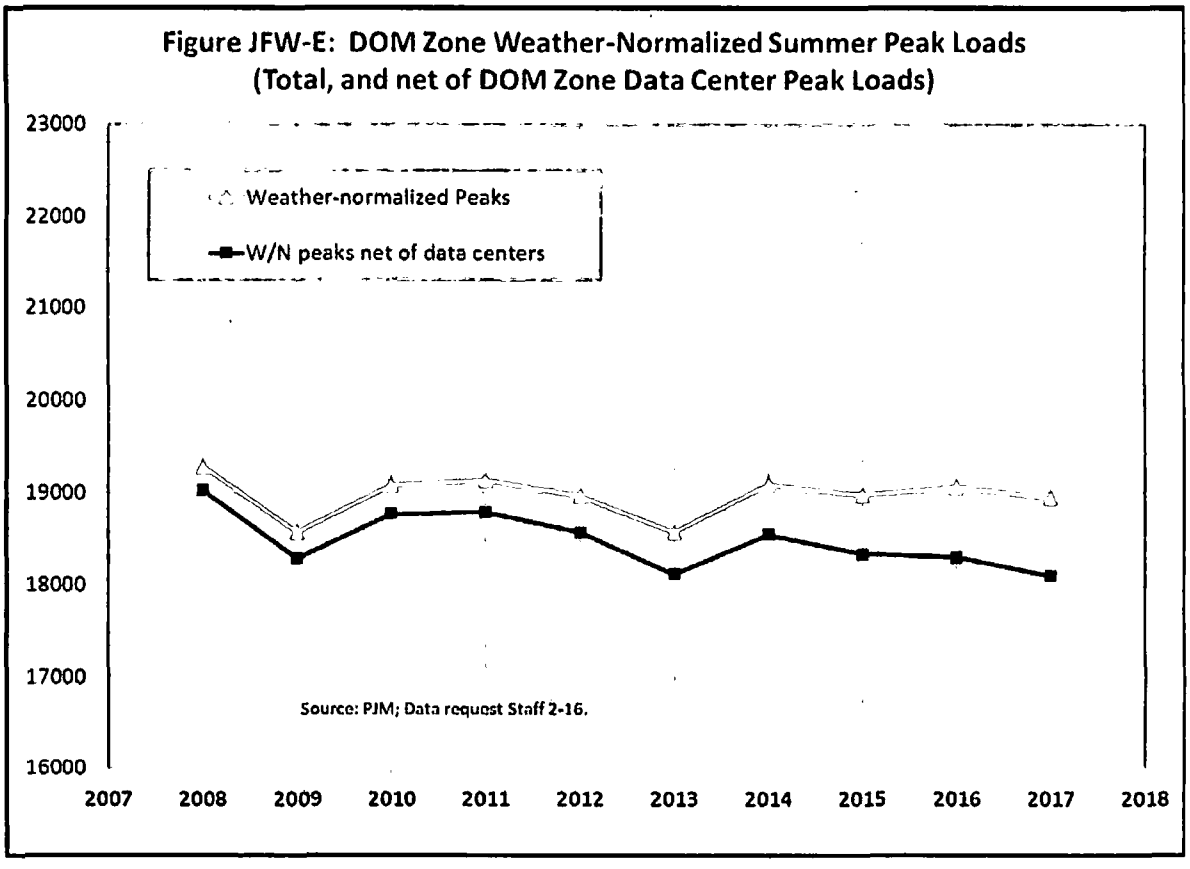
[10] Itron, Inc., *2013 Weather Normalization Survey*, March 2014, available at http://capabilities.itron.com/efg/Reports/Itron_WeatherNormalizationReport2013.pdf.
[11] Response to Data Request ER 1-14.
[12] PJM, *Weather Normalized Peaks*, supplemental materials to the 2018 Load Forecast Report, available at http://www.pjm.com/-/media/planning/res-adeq/load-forecast/weather-normalized-peaks.ashx?la=en.
[13] PJM, *Weather Normalization of Peak Load*, Load Analysis Subcommittee meeting September 2, 2015, Item 3, available at http://www.pjm.com/~/media/committees-groups/subcommittees/las/20150902/20150902-item-03-weather-normalization.ashx.
[14] See, for instance, PJM, *Weather Normalization*, Load Analysis Subcommittee meeting July 18, 2018 Item 6, available at http://www.pjm.com/-/media/committees-groups/subcommittees/las/20180718/20180718-item-06-weather-normalization.ashx.



the post-recession period (from about 2010 to the present), peak loads have been flat; the 2017 and 2010 values are also very close.

Q 27: The 2018 Plan notes recent and anticipated growth in data center loads (pp. 17, 22). Why hasn't this growth resulted in an upward trend in peak loads in the DOM Zone?

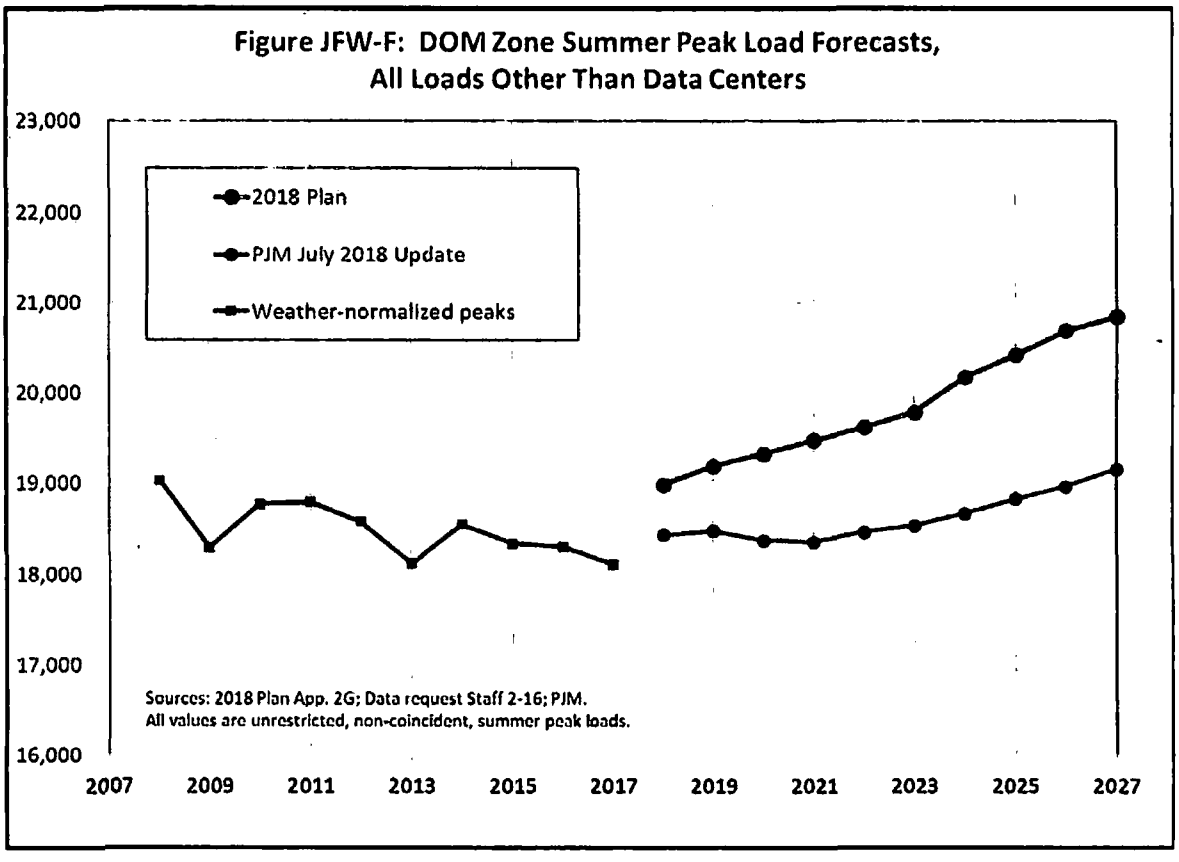
A: There has been strong growth in demand by data centers. However, this has only offset a declining trend in the peak loads of all other customers. Figure JFW-E shows the weather-normalized peak loads for all DOM Zone loads other than the data center peak loads. The trend in the Company's peak load for all customers other than the data centers is actually down over the past decade: the weather-normalized peaks for 2015 through 2017 are lower than for 2010 through 2012.



Q 28: Now please present the Company's peak load forecast for the DOM Zone, focusing first on the forecast for all customers other than the data centers.

A: Figure JFW-F presents the Company's forecast that was relied upon for the 2018 Plan (Appendix 2G), showing the forecast for all loads other than the data center loads. The summer peak loads are shown; while annual actual peaks have occurred in winter, this is rare, and the Company continues to consider the zone summer-peaking on a forecast basis.[15] As in its prior forecasts, the Company's current forecast suggests robust growth in peak loads, starting right in 2018, even for the loads other than data centers that have been declining over the past decade.

[15] 2018 Plan p. 18.



Q 29: Please compare the Company's forecast to PJM's.

A: Figure JFW-F also shows the latest PJM DOM Zone forecast, based on its July 2018 forecast update, for all loads other than data centers.[16] The mid-year update is based on economic and demographic projections from May 2018, and various other updates since the January 2018 forecast release. For its mid-year update, PJM publishes coincident peak forecasts for 2018 through 2021; so the updated non-coincident peak forecast shown here is estimated based on the ratios of non-coincident to coincident peaks from the 2018 Load Forecast Report, which are very stable over time.

PJM's forecast is considerably lower than the Company's. PJM's forecast is over 1,000 MW lower than the Company's for 2021, growing to more than a 2,200 MW difference by 2026.

Q 30: Please comment on the consistency of these forecasts with recent trends.

A: As Figure JFW-F clearly suggests, the Company's forecast breaks sharply with recent trends. While peak loads for loads other than data centers have been declining, the Company forecasts strong growth. PJM's forecasts are somewhat more consistent with recent trends, but still anticipate peak load growth in the near term faster than recent trends suggest.

Q 31: Please describe the Company's approach to forecasting peak loads.

A: The Company uses an econometric regression model that takes some inputs from a separate model of sales by customer class. The regression model forecasts peak loads based on various economic and demographic independent variables (shown in Figure 2.2.6 and Appendix 2K; forecasts from October 2017). The methodology is described in the 2018 Plan at pp. 15-22 and in a separate forecast methodology document.[17]

Q 32: What are the primary drivers of peak load growth under the Company's forecasting methodology?

A: The Company's econometric approach relies upon various economic and demographic forecasts as independent variables that drive future peak load growth. These are summarized in Figure 2.2.6 in the 2018 Plan, and include trends in the number of customers and households, per capita income, and employment. However, the Company states (2018 Plan p. 21), that the forecast of the Virginia economy is a "key driver" of the forecast.

[17] Dominion Energy Electric Load Forecast Models Documentation, May 2018, response to Data Request ER 1-4(a) (KS).

Q 33: The 2018 Plan states (p. 21) that the Virginia economy is expected to "rebound further" within the Planning Period. Do anticipated economic and demographic trends support the Company's forecast of a sharp change to robust growth in peak load?

A: No; the trends in these independent variables have been rather steady recently, and they are expected to continue to show moderate but steady increases over the forecast period, as shown in Figure 2.2.6 in the 2018 Plan. These forecasts do not explain the sharp deviation from trend reflected in the Company's peak load forecast.

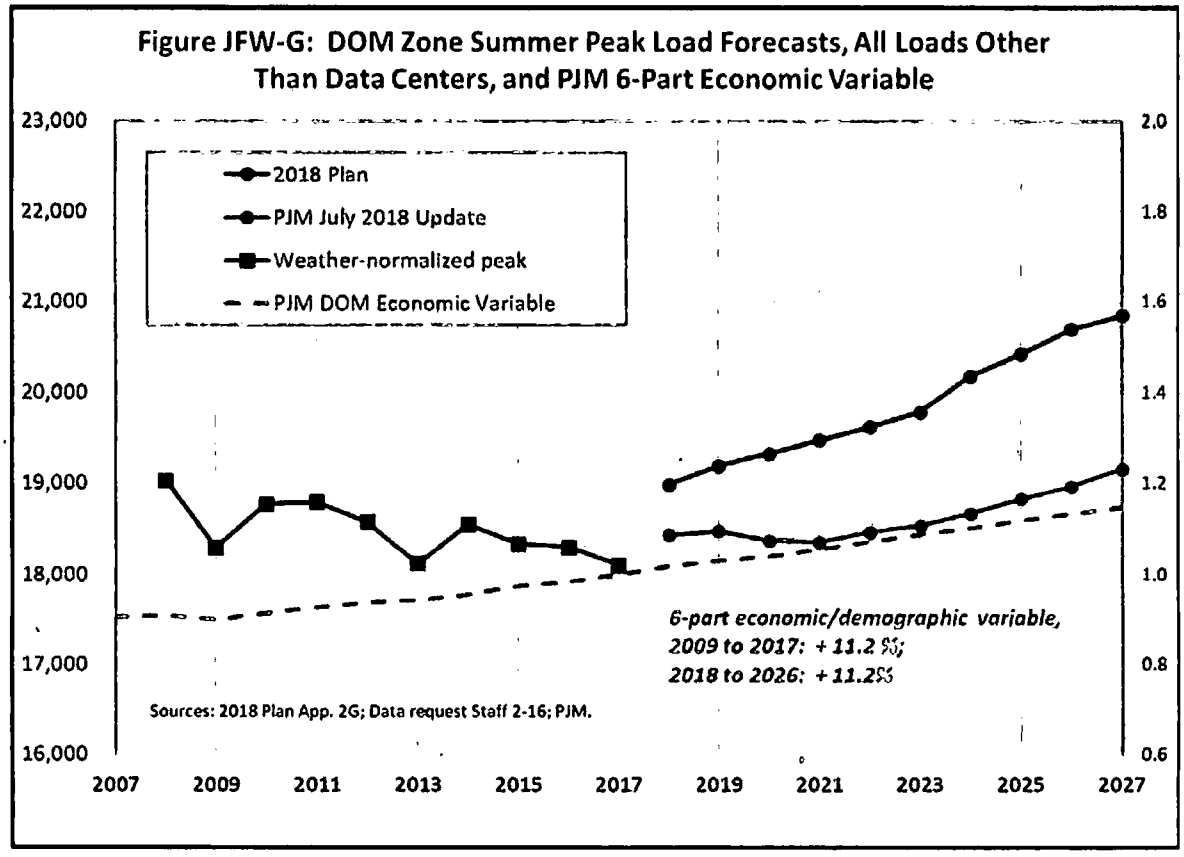
Q 34: Is there a way to compare the economic and demographic trends and forecasts to the peak load trends and forecast?

A: Yes. A sound approach is to compute a "composite index" that combines the various economic and demographic measures into a single index. Then the history and projections of the index can be compared to the peak load history and projections.

The Company has not prepared such an index.[18] However, PJM prepares and published such indices together with its forecasts.[19]

Figure JFW-G shows the composite index for the DOM Zone economic and demographic variables used by PJM in its January 2018 forecast for the DOM Zone. This index combines five DOM Zone-specific economic-demographic variables (households, population, personal income, non-manufacturing employment, and state or metropolitan product) and U.S. GDP.[20] These are the same or similar economic-demographic

[18] Response to Data Request ER 1-26.
[19] PJM, *2018 Economic Variable Data*, available at http://www.pjm.com/-/media/planning/res-adeq/load-forecast/2018-economic-variable-data.ashx?la=en.
[20] PJM, *PJM Manual 19: Load Forecasting and Analysis*, Revision: 31 Effective Date: 06/01/2016, p. 18, available at http://www.pjm.com/~/media/documents/manuals/m19.ashx.



variables used by the Company in its forecasting, and sourced from the same vendor (Moody's economy.com).

Q 35: Please discuss how the composite economic-demographic index compares to the peak load forecasts.

A: Figure JFW-G shows that while DOM Zone peak loads for these customers were declining over the past decade, the economic-demographic index continued to climb. The figure further shows that while the economic-demographic variable is expected to continue to rise in future years, it generally continues the past trend.

In particular, the six-part economic and demographic variable increased by 11.2 percent over the eight-year period from 2009 to 2017, and is expected to increase by that same percentage, 11.2, over the eight-year period from 2018 to 2026. Thus, these economic

and demographic trends provide no reason to expect future peak loads to break from past trends.

Q 36: How can peak loads remain flat or decline while the economic and demographic drivers are increasing, as has occurred over the past decade?

A: Peak loads can be flat or declining while economic and demographic measures rise due to the increased penetration of more energy-efficient appliances; people and businesses are doing more with electricity, while using less electricity.

Q 37: If the economic and demographic forecasts do not point to robust growth in peak loads, why does the Company's peak load forecast rise so sharply?

A: The primary reason the Company's forecasts suggest robust peak load growth is that the Company's forecasting methodology bases the forecast trends on thirty years of historical data.[21] This prevents capturing and reflecting recent trends in peak load growth, even if such trends extend for a decade, as the current trend now has.

Many years ago, the DOM Zone, and other regions of the country, did indeed experience much faster peak load growth. However, more recently, there has been a trend of slowing peak load growth, both in absolute terms, and in relation to economic and demographic growth. Including the long-ago history in the Company's forecasting leads the model to discount the more current trends from the past decade, and place undue weight on the higher rates of peak load growth seen ten to thirty years ago.

Q 38: Please describe PJM's approach to forecasting peak loads for the DOM Zone and compare it to the Company's approach.

A: PJM also uses an econometric approach based on similar economic and demographic forecasts. While there are numerous differences between the Company's and PJM's

[21] Response to Data Requests ER 1-6, ER 1-11.

econometric models (of which some are described in the 2017 Plan at pp. 25-29), three are likely the most important factors leading to the different results:

1. PJM uses a 19-year historical period for estimating the model, while the Company uses 30 years. As a result, PJM's forecast will reflect recent trends to a somewhat greater extent.

2. PJM's methodology has recently been enhanced to better capture trends and projections regarding appliance saturation and energy efficiency.

3. PJM commissions a separate forecast of distributed solar generation and combines it into its forecast (as Table B-8 of its load forecast reports).

Q 39: The 2018 Plan asserts that the differences between PJM's and the Company's forecasts are due to methodological differences that were explained in the 2017 Plan, and that these differences still exist. First, please summarize your response to that discussion from the 2017 Plan.

A: The discussion at pp. 25-29 of the 2017 Plan identified changes to PJM's forecast that purportedly close the gap between the Company's and PJM's forecasts. I reviewed the claims in my testimony last year (cited above), and summarized my review as follows:

1. The adjustments for data centers and DERs were not warranted and would not be an improvement to PJM's methodology, even if correctly applied (which they were not; both of the Company's adjustments reflected errors).

2. While there is always potential for improvements to the forecasting of appliance saturation and efficiency, the Company's "adjustment" apparently removed this important enhancement to PJM's approach. This too would not be an improvement.

3. Separately forecasting the Public Authority sector could potentially improve a load forecast; however, the Company provided no explanation of why it would, and its

forecast adjustment embedded a huge increase in government loads at a time when the current administration has announced intentions to reduce government.

In my testimony last year, I concluded that none of the proposed adjustments was warranted or would improve PJM's forecast. My conclusion that PJM's forecast was likely to be more accurate than the Company's was unchanged by that analysis.

Q 40: Did the Company update its comparison to the PJM forecast, using the forecast presented in the 2018 Plan and the PJM 2018 forecast?

A: No. The Company provided no updated narrative discussing the differences, and provided no updated workpapers for the alleged differences.[22] My conclusion remains that PJM's forecast is likely to be more accurate than the Company's.

Q 41: Does PJM continue to review its methodology and explore additional possible enhancements?

A: Yes. For example, this year PJM staff are exploring using separate models of weather-sensitive and non-weather-sensitive peak loads to improve the forecast accuracy.[23]

Q 42: Does the Company also evaluate and enhance its load forecasting methodology over time?

A: Apparently not. In response to a data request asking about enhancements to the methodology over the past twenty years, the Company noted no changes to its methodology, only to data (a 2016 update to appliance saturation and intensity data).[24] The Company also states that it "does not systematically conduct accuracy analyses or studies of its previous Integrated Resource Plan load forecasts" and could provide no

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[22] Responses to Data Requests ER 6-6 and ER 1-30.
[23] See, for instance, PJM, *Load Forecast Model Development*, Load Analysis Subcommittee meeting July 18, 2018 Item 4, available at http://www.pjm.com/-/media/committees-groups/subcommittees/las/20180718/20180718-item-04-load-forecast-model-development.ashx.
[24] Response to Data Request ER 1-7.

documents pertaining to the accuracy of its forecasts.[25] In particular, the Company states that it has not evaluated using a historical period shorter than the 30 years it has been using, but could provide no explanation for why it had not explored alternative historical periods other than to maintain "consistency."[26]

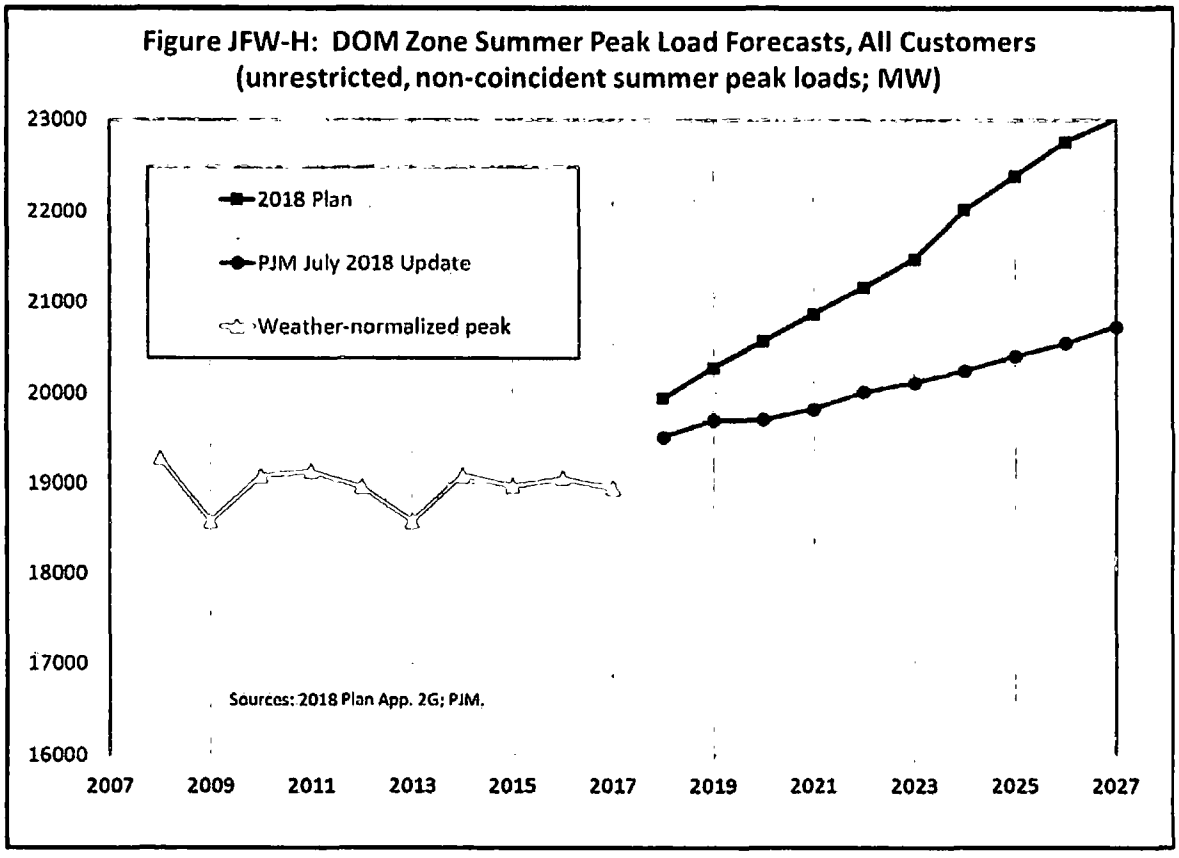
Q 43: The 2018 Plan suggests (p. 22) that PJM has substantially increased its DOM Zone peak load forecast since its prior, 2017 forecast. Is this correct?

A: No. PJM's 2018 forecast is lower than PJM's 2017 forecast for years 2018 through 2021, and about one percent higher through 2024. PJM's mid-year update is about one percent lower than its January 2018 forecast. The 2018 Plan cited figures for fifteen years out.

Q 44: You mentioned the strong growth in data center demand. Please present the forecasts, including the forecasted data center growth.

A: Figure JFW-H shows the weather-normalized history and the forecasts, now including the projections for data centers. Figure JFW-H shows that the Company's data center forecasts (which are highly speculative, and discussed in detail in the next section of this testimony) do not explain the sharp break in the Company's forecast from past trends.

[25] Response to Data Request ER 1-9.
[26] Response to Data Request ER 1-12.



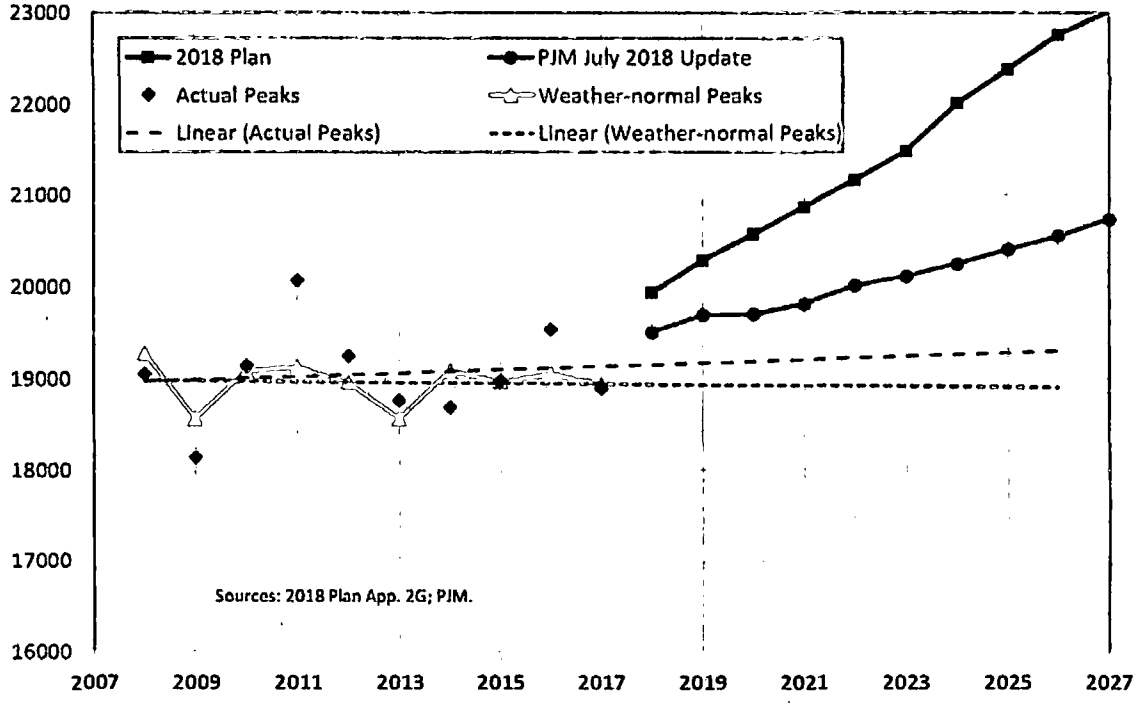
Q 45: You noted that the economic and demographic trend is expected to be about the same over the coming eight years as over the past eight years. How will peak loads change over time, if the recent trends simply continue?

A: This is shown in Figure JFW-I. For this figure I simply add linear trend lines based on the ten years of actual summer peaks from 2008 to 2017 (green dashed line) and based on the weather-normalized summer peaks over the same period (orange dashed line). These projections show that if current trends continue, peak loads will remain flat.

Q 46: Please summarize your conclusions from this section of your testimony.

A: The Company continues to forecast robust peak load growth for the DOM Zone, even for loads other than data centers, despite the decade-long trend of declining peak loads. PJM's forecast is lower but still suggests a rate of growth inconsistent with the recent trend. Both forecasts are very likely to be too high, but PJM's is more reasonable.

Figure JFW-I: DOM Zone Summer Peak Load Forecasts, With Trends
(unrestricted, non-coincident summer peak loads; MW)



IV. DATA CENTER LOAD FORECAST AND FORECAST ADJUSTMENT

Q 47: You mentioned that both the Company and PJM adjust their econometric peak load forecasts to take into account the anticipated growth in data center loads. Please explain the rationale for such adjustments.

A: The Company is concerned that its econometric forecasting approach will fail to accurately forecast the growth in data center loads, because the growth trend is fairly recent. Accordingly, the Company prepares a separate forecast of data center sales and

peak loads, and uses it to adjust their forecast. PJM also adjusts its forecasts, based on data center forecasts provided to it by the Company.[27]

Q 48: How are such adjustments for data center load growth determined?

A: The general approach is to 1) prepare a separate forecast of the data center peak loads, 2) estimate how much future data center peak load growth is already projected by the econometric forecasting (the "embedded" amount), and then 3) subtract the embedded amount from the forecast amount, to determine the amount of future growth that is not captured by the econometric model, and that should be added to the forecast.

Q 49: How has the Company prepared its forecasts of data centers peak loads?

A: For recent Plans through the 2017 Plan, the Company relied upon studies prepared in 2013 and again in 2015 by Quanta Technology,[28] in addition to internal forecasts. The Quanta Technology reports provided forecasts of future data center peak loads along with estimates of the amount of the load growth that is captured by the type of econometric forecasting methods used by the Company. However, this year the Company took a much simpler approach, using a simple S-shaped curve fitted to historical data ("Bass Diffusion Model") to project future data center loads based only on historical trends.[29]

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[27] PJM's general approach to such load forecast adjustments is documented in PJM, *PJM Manual 19: Load Forecasting and Analysis*, Revision: 32 Effective Date: December 1, 2017, Attachment B: Load Forecast Adjustment Guidelines, available at http://www.pjm.com/~/media/documents/manuals/m19.ashx.

[28] Quanta Technology, *Dominion Northern Virginia Load Forecast Dominion Virginia Power*, Oct. 23, 2015 ("2015 Quanta Report") and Quanta Technology, *Dominion Northern Virginia Load Forecast Dominion Virginia Power*, Oct. 17, 2013.

[29] Response to Data Request ER 6-3 "The data center load forecast is derived using a Bass Diffusion Model, which is a standard modeling approach for forecasting the adoption of new technologies."; response to Data Request ER 1-36, referring to the response to Data Request Staff 2-16 attachment; and response to Data Request ER 1-4(a) (KS), Dominion Energy Electric Load Forecast Models Documentation, May 2018, pp. 6-9.

Q 50: Before getting into the details of this new forecasting approach, what research, data or analysis did the Company rely upon in preparing its data center forecast?

A: Apparently, none. The Company has no research or analysis supporting its forecast of data center loads.[30] The Company refers to a spreadsheet prepared by witness Eric Fox of Itron in connection with his Rebuttal Testimony in the 2017 Plan proceeding (Case No. PUR-2017-00051), which includes no data center data or analysis, only the Bass Diffusion Model equation.[31]

Q 51: Is the Company in possession of firm evidence of specific new data centers or data center expansions in 2019 or later years?

A: The Company is apparently not in possession of firm evidence of new data center loads.[32] The Company can only refer to "significant interest" by data centers, citing 58 "potential" projects totaling a potential 3,883 MW, but noting that these are not "committed projects."[33] The Company states that it did not rely on this information to prepare its forecast, due to "the speculative nature of the information."[34]

Q 52: While the Company did not base its data center forecast on any firm evidence that there will be further data center expansions, please explain how the Company prepared its forecast.

A: The Company simply fitted an S-shaped curve ("Bass Diffusion Model") to the historical data center loads, and used the extension of the S-shaped curve as its forecast. This approach to projecting data center loads was first applied by Company witness Fox on rebuttal last fall in connection with the 2017 Plan.

[30] Response to Data Requests ER 1-36a, ER 1-37g, ER 6-3.
[31] Response to Data Request ER 6-5, referring to the response to ER 1-37; see also response to ER 1-36a.
[32] Response to Data Request ER 6-12, referring to the response to ER 6-4 (referring to "potential" data center projects); see also response to Data Request ER 9-4.
[33] Response to Data Request ER 9-4.
[34] Response to Data Request ER 9-3.

Q 53: Is using the Bass Diffusion Model curve a sound approach to projecting data center loads?

A: No, this is not a sound approach; it is highly arbitrary, and can be applied to produce just about any desired forecast, as I will show. The Company has not provided any evidence that this approach is used for forecasting, pointing only to Mr. Fox's testimony from last year's proceeding.[35] Mr. Fox only testified that the Bass Diffusion Model is "a common approach for fitting an S-shaped curve," but made no claim that the approach was used for forecasting.[36]

Q 54: While you question the use of the Bass Diffusion Model curve for forecasting, has the Company applied the approach to the historical data in an accurate manner?

A: No. The S-shaped curve should be selected based on the best fit to the historical data, but the curve the Company is using for its forecast is not the best-fitting curve. In addition, the approach to selecting the curve reflects other totally arbitrary choices that have a substantial impact on the resulting forecast.

Q 55: How did the Company fit the Bass Diffusion Model curve to the historical data, to produce its data center forecast?

A: The Company does not know how the curve was fit or even what measure was used.[37] The Company used the curve parameters chosen by Mr. Fox, who did not document how he chose them.[38] Furthermore, while the Company has updated the historical data, the Company did not update the curve, but simply used the curve developed by Mr. Fox last year, based on less historical data.[39]

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[35] Response to Data Requests ER 4A-1a and ER 9-2.
[36] Itron, *2017 Long-Term Electric Energy and Demand Forecast and Review*, September 6, 2017, p. 34.
[37] Response to Data Request ER 6-13 a, b.
[38] Response to Data Requests ER 4A-1a and ER 4A-1b, referring to the Fox 2017 testimony and to the response to Data Request Attachment Staff Set 2-16 (KS), which do not describe how the fit was performed.
[39] Response to Data Request 4A-5 (describing the updated data).

Q 56: You stated that the S-shaped curve used by the Company is not the best-fitting curve. Please elaborate.

A: Two standard measures of good fit are Mean Absolute Percent Error ("MAPE") and Root Mean Squared Error ("RMSE"). According to either or both of these standard measures, other, very different curves (resulting in very different forecasts) fit the historical data better than the curve selected by Mr. Fox and used by the Company.

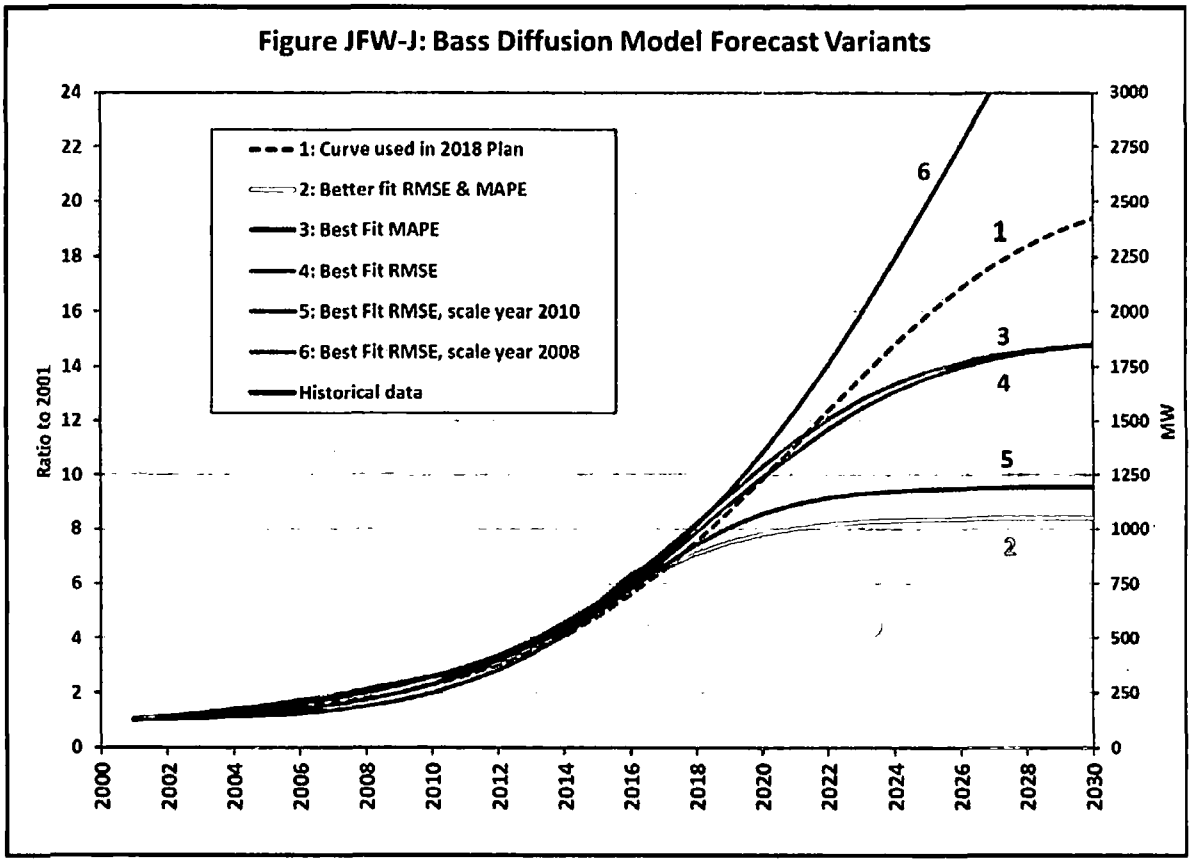
Figure JFW-J shows the curve used in the 2018 Plan (#1 in the graphic) and several alternate curves. Curve #2 fits the data better according to both MAPE and RMSE, and results in a forecast that tops out below 1,100 MW, far below the Company's chosen curve. Curves #3 and #4 are the best-fitting curves according to MAPE and RMSE, respectively.

Q 57: You stated that the S-shaped curve used by the Company reflects other arbitrary choices. Please elaborate.

A: Mr. Fox "scaled" the historical data before performing the fit, using 2009 as the year for which the scaled data would equal 1.0. The Company does not know why Mr. Fox chose 2009, or whether using a different year would make any difference.[40] I tested the impact of using a different year for this scaling, such as 2008 or 2010. When a different year is used, the resulting best-fitting curve is entirely different, and results in an entirely different data center forecast, as also shown in Figure JFW-J. Curves #5 and #6 compare to curve #4 (best fit using RMSE), with the data scaled to 2010 and 2008, respectively.

In addition, there was apparently no historical data from before 2010, but Mr. Fox fabricated such data, creating a value for each year from 2001 through 2009 set to 90% of

[40] Response to Data Request ER 6-17.



the following year.[41] These additional, fabricated data points were nevertheless included in the range used by Mr. Fox to fit the S-shaped curve.[42]

Q 58: While the data center forecast based on the Bass Diffusion Model approach is apparently quite arbitrary, did the Company incorporate this separate data center forecast into its overall 2018 Plan peak load forecast in a correct manner?

A: No. As I described, the correct approach is to determine the amount of anticipated future data center load already embedded in the econometric forecast, and only add the additional amount necessary such that the total equals the separate data center forecast. However, apparently the Company did not pursue this approach. The Company

[41] Response to Data Request ER 6-14d.
[42] Response to Data Request ER 6-13c.

acknowledges that its commercial model includes historical and projected data center loads,[43] but states that it did not identify and does not know the embedded amount.[44] This suggests that the future data center load growth embedded in the Company's econometric forecast may be double-counted in the Company's load forecast.

Q 59: Now please describe how PJM determined its data center forecast and forecast adjustment.

A: PJM relied upon the forecast provided by the Company for 2018 through 2022.[45] Beyond 2022, PJM held the data center peak load values constant, because projections were not available beyond 2022.

PJM updated its estimates of the amount embedded in its forecasting model, and subtracted these values from the data center forecast, resulting in the forecast adjustments shown in Table B-9 of the 2018 Load Forecast Report. Thus PJM, unlike the Company, correctly determined the appropriate amount for the forecast adjustment.

Q 60: How certain is any forecast of rapid growth in data center loads?

A: The growth is highly uncertain; it could be considerably different from the forecast. The 2015 Quanta Report noted (p. 13) that data center owners are "deliberately optimistic in giving the utility completion dates and future loads," because they want no utility-side constraints on when they can get the power they need.

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[43] Response to Data Request ER 9-7a, b.
[44] Response to data requests ER 6-15c, 9-7c.
[45] PJM, *Load Forecast Adjustment - Dominion*, PJM Load Analysis Subcommittee meeting Item #4, November 15, 2017, p. 2, available at http://www.pjm.com/-/media/committees-groups/subcommittees/las/20171115/20171115-load-forecast-adjustment-dominion.ashx.

While it may be very likely that there will be strong growth in electric demand for data centers in North America, at least in the near term, it is highly uncertain when and where that growth will occur. And a report by Lawrence Berkeley National Laboratory suggests that increasing energy efficiency at data centers will result in little additional growth in their electricity demands at the national level in the coming years, despite strong growth in the demand for their services:[46]

> "The combination of these efficiency trends has resulted in a relatively steady U.S data center electricity demand over the past 5 years, with little growth expected for the remainder of this decade. It is important to note that this near constant electricity demand across the decade is occurring while simultaneously meeting a drastic increase in demand for data center services; data center electricity use would be significantly higher without these energy efficiency improvements."

The 2015 Quanta Report also noted this possibility; it states that as existing and new data centers upgrade to new technologies, "their electric loads could drop substantially."[47]

Q 61: Has the Company researched whether the owners of the data centers are pursuing efforts to become more energy efficient?

A: No. The Company states that it has not conducted formal research of this question, and has made no explicit assumption regarding efficiency improvements.[48]

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[46] U.S. Department of Energy, Ernest Orlando Lawrence Berkeley National Laboratory, *United States Data Center Energy Usage Report*, June 2016 (LBNL-1005775), p. ES-2, available at http://eta.lbl.gov/sites/all/files/lbnl-1005775_v2.pdf.
[47] 2015 Quanta Report p. 26.
[48] Response to Data Request ER 1-42.

Q 62: Is there evidence that the existing data centers are reducing their peak demands through efficiency improvements?

A: Yes. In response to a data request, the Company provided historical hourly loads for a "representative data center customer."[49] This large, representative customer reduced its energy and peak demands each year from 2014 to 2017, and consumed only 68% as much energy in 2017 as in 2014.

Q 63: Have some of the companies that build and operate data centers also announced intentions to increasingly rely on renewable sources of energy?

A: Yes, a number of these companies have announced such intentions over the past few years. These commitments are summarized in a report by Greenpeace.[50]

This report notes (p. 30) that of five U.S. "hot spots" for data center investment, Northern Virginia ranks low, and far behind Northern California and Dallas with regard to access to renewable energy; this suggests that the firms committing to renewable energy may increasingly choose other regions of the country for their data center expansions.

Q 64: Has the Company taken such intentions into account in the 2018 Plan?

A: Apparently not. The Company states that only "quantifiable, proven and firm" parameters are taken into account in the integrated resource planning ("IRP") process, and that such owners' "intentions" to rely on renewable sources of energy do not constitute observable quantities, so they are not part of the IRP process or modeling.[51] However, the Greenpeace report (Appendix II: Company Scores Explained) documents

[49] Response to Data Request Staff 7-92b, Confidential Attachment Staff Set 7-92(b) (supp 6-26-2018).
[50] Greenpeace, *Clicking Clean: Who Is Winning the Race to Build a Green Internet?*, June 2017, available at http://www.clickclean.org/downloads/ClickClean2016%20HiRes.pdf.
[51] Response to Data Request ER 1-43(b).

announced commitments by many of the leading companies in this industry, which appear to reflect more than just intentions.

Q 65: What is your conclusion and recommendation with respect to the DOM Zone data center peak load forecast for the 2018 Plan?

A: This forecast is unsupported and highly speculative; while there likely will be additional new data centers, it is also likely true that the loads of existing data centers will be shrinking. In addition, the Company has apparently not incorporated its separate data center forecast into its overall forecast correctly. The Commission should focus on the forecast for all other customers, as shown in the above figures, and consider the future changes in data center load highly uncertain.

V. DOMINION LOAD-SERVING ENTITY PEAK LOAD

Q 66: Turning now to the DOM LSE peak load forecast, how was this forecast prepared for the 2018 Plan?

A: The Company determined the DOM LSE adjusted peak load forecast (Appendix 2I line 6) that is used in the TRR calculations as follows:

1. The starting point was the Company's forecast summer peak load for the DOM Zone (Appendix 2G), discussed earlier in this testimony.

2. Then the DOM LSE utility peak load "base forecast", shown in Appendix 2I line 1a, was determined as a simple percentage (87.4%) of the DOM Zone forecast in each year.

3. The DOM LSE "base forecast" was adjusted for conservation and efficiency (Appendix 2I, line 2) to determine the DOM LSE adjusted peak load forecast shown at Appendix 2I line 6 and Figure 4.2.2.1 column 5, and used for the TRR calculations.

Q 67: How did the Company determine the 87.4% factor used to represent DOM LSE as a fraction of the DOM Zone peak load?

A: The 2018 Plan states (p. 17) that this was based on "a regression of historical DOM LSE loads onto historical DOM Zone loads" and claims that "the estimated coefficients are applied to the projected zonal loads resulting in a load forecast for the DOM LSE."

The details of the calculation were provided in response to a data request.[52] The regression was based on the July actual peak loads for DOM Zone and DOM LSE over 2008 through 2017. The Company then assumed DOM LSE over the coming years would represent the same constant fraction of DOM Zone peak load (87.4%) as it had over this ten-year historical period.

Q 68: Is this an accurate way to forecast the DOM LSE portion of the DOM Zone peaks?

A: No. The peak loads of the Other LSEs in the DOM Zone are rising faster than DOM LSE peak loads and represent an increasing fraction of the DOM Zone peak over time. This trend is reflected in the historical data provided by the Company in support of the 87.4% factor it is using.

The Other LSEs in the DOM Zone are Old Dominion Electric Cooperative ("ODEC"), Northern Virginia Electric Cooperative ("NOVEC"), Central Virginia Electric Cooperative ("CVEC"), and North Carolina Electric Membership Cooperative ("NCEMC"). The faster load growth of these Other LSEs reflects, perhaps among other factors, the strong growth in data center loads served by NOVEC. This trend is also

[52] Data Request ER-1-20(a) attachment.

reflected in data provided to the Company by some of the Other LSEs, and provided through discovery.

Q 69: Please summarize the data regarding Other LSEs loads provided through discovery.

A: While the Company stated that it does not have historical or forecast energy or peak load information about any of these other LSEs,[53] the Company did ultimately provide some data through discovery.[54] This data shows NOVEC's load projections for its delivery points, excluding and including "large customer inquiries". This data shows that NOVEC expects it load to grow by 25 percent from 2018 to 2022, *excluding* the potential new large customers, or 37%, if these potential new large customers are included.

NOVEC's annual reports reveal that from 2009 to 2017, its sales grew steadily, by a total of 38% over this period (over 1,200 GWh, and 4.1% per year on average). By contrast, DOM LSE sales grew a total of 4.3% over the same period (0.5% per year), according to the 2018 Plan, Appendix 2A.

Q 70: How did the Company use such information about Other LSEs' load growth in projecting the DOM LSE's share of the zone peak load growth.

A: The Company states that it did not use this information:[55]

> "NOVEC's load projections were not used to develop the load forecast in the Company's 2018 Plan, nor were any other DOM Zone LSEs' load projections or forecasts of sales or peak loads."

[53] Response to Data Request ER 1-20e.
[54] Response to Data Request ER 6-10, Attachment ER Set 6-10 (RB).
[55] Response to Data Request ER 9-5 a-b.

Q 71: Turning back to how the Company estimated the DOM LSE's share, please elaborate regarding the trend in Other LSE peak loads reflected in the Company's data.

A: To calculate the 87.4% factor for the DOM LSE share, the Company used a regression over a ten-year historical period. This regression identifies the trend toward a growing share of Other LSE peak loads, and suggests that the Other LSE share, which was 12.8% in 2017, would rise to 13.6% by 2029.

However, to develop its forecast of the future DOM LSE peak loads, the Company ignored this trend, and simply applied the historical average (87.4% for DOM LSE, 12.6% for Other LSEs) throughout the forecast period.

Q 72: Have you prepared an alternative estimate of the DOM LSE portion of future DOM Zone peak loads?

A: Yes. My preferred method would be to separate out the data center loads, and to project the DOM LSE/Other LSE split separately for data centers and for all other loads. However, the Company did not provide the data that would be needed to do this.

Instead, I simply used the Company's regression, discussed above, that projects the DOM LSE share to decline slowly from 87.3% in 2017 to 86.3% by 2033. This has a modest impact on the forecast of DOM LSE peak loads; it reduces them by 44 MW in 2019, 103 MW in 2022, and 270 MW by 2033, based on the Company's DOM Zone forecast. This very likely overstates the DOM LSE share of the DOM Zone peak load.

VI. RESERVE MARGINS AND TOTAL RESOURCE REQUIREMENTS

Q 73: Please describe how the Company calculated its Total Resource Requirements ("TRR").

A: The annual TRR values shown in Figure 4.2.2.1 were calculated as follows (references are to 2018 Plan appendices):

1. The starting point was the Company's DOM Zone peak load forecast shown in Appendix 2G and discussed in earlier sections of this testimony.

2. Then the Company determined the LSE adjusted peak load, shown at Appendix 2I line 6 and Figure 4.2.2.1 column 5, as discussed in the prior section. An adjustment for conservation and efficiency (Appendix 2I line 2) is also reflected in the LSE adjusted peak load.

3. The reserve requirements (reserve margins), shown in the sixth column of Figure 4.2.2.1, were determined by multiplying the DOM LSE adjusted peak load (step 2 above) by an "effective reserve margin" of 11.74 percent, determined as the product of two components:

   (a) a "coincidence factor", to estimate the DOM LSE PJM RTO-coincident peak load based on the non-coincident peak load (0.9647; 2018 Plan p. 53); and

   (b) PJM's recommended installed reserve margin for 2021/2022 (15.9%).

4. Finally, the Total Resource Requirement for each year (final column of Figure 4.2.2.1) was the sum of the DOM LSE adjusted peak load and the reserve margin. The Total Resource Requirement is expressed in installed capacity terms.

Q 74: Does the Company's approach to calculating reserve margins and capacity needs match how capacity obligations are determined in PJM?

A: No. Capacity obligations in PJM are determined beginning with PJM's forecast of coincident peaks (Table B10 in its load forecast reports), and by applying the Forecast Pool Requirement ("FPR") to the coincident peaks to determine capacity obligations on an "unforced" capacity ("UCAP"), as opposed to installed capacity, basis.[56]

The Company instead used the installed reserve margin to determine capacity obligations. In addition, the Company used a single value for the installed reserve margin (15.9%) for all years, while the PJM study that identified this reserve margin recommended values by year through 2027, and the reserve margin and FPR values vary over time. In addition, the Company used a single coincidence factor (averaged over 2018-2021) for all years, to estimate coincident peaks. PJM forecasts coincident and non-coincident peaks by year, so the coincidence factor varies from year to year.

However, while the Company's approach differs from PJM's, the results are likely very similar.

Q 75: Have you calculated the Total Resource Requirements based on the load forecast and reserve margin values you recommend?

A: Yes I have. My estimates of the TRR values reflect the following differences from the Company's estimates:

[56] PJM, *Planning Period Parameters for the 2021-2022 Base Residual Auction*, tab 2021-2022 Parameters (showing that the Reliability Requirement is calculated based on the FPR, and the installed capacity reserve margin is used only in the calculations of the shape of the VRR curve), available at http://www.pjm.com/-/media/markets-ops/rpm/rpm-auction-info/2021-2022/2021-2022-bra-planning-period-parameters.ashx?la=en.

1. I used PJM's latest DOM Zone forecast (July 2018), as discussed in an earlier section of this testimony.

2. I re-estimated the DOM LSE peak load using the Company's regression for this purpose, as described in an earlier section of this testimony, and applied the same conservation and efficiency adjustment.

3. I applied the Company's effective reserve margin values to determine the reserve margin and TRR in all years.

The results of the calculation were shown above in Table 1.

Q 76: The 2018 Plan states (p. 52) that the Company, as a PJM member and signatory to PJM's Reliability Assurance Agreement ("RAA"), is obligated to own or procure sufficient capacity to maintain overall system reliability. Is it correct that the RAA obligates the Company to own or procure capacity?

A: No. PJM acquires commitments to provide the capacity needed for resource adequacy through its Reliability Pricing Model ("RPM") capacity construct. The RAA assigns capacity responsibility for the purpose of allocating RPM costs to zones and to LSEs. However, the RAA does not obligate the Company (or any other party) to own or procure capacity; its references to "capacity obligations" ultimately have to do with cost allocation, as the Company acknowledges.[57] Indeed, many LSEs in PJM do not own capacity or have capacity under contract.

[57] Response to Data Request ER-1-44c.

Q 77: The 2018 Plan also states (p. 54) that the TRRs represent "the Company's total resource need that must be met through existing resources, construction of new resources, DSM programs, and market capacity purchases." Is this an accurate characterization of what the TRRs represent?

A: No. Again, capacity obligations in PJM have only to do with cost allocation.

Q 78: The 2018 Plan (p. 54) also identifies an "upper bound reserve margin", and states that the Company "may be required" to meet this reserve margin in the future. Is this correct?

A: No. Again, PJM does not require acquisition of capacity or any particular reserve margin. The relevant calculations are only for purposes of cost allocation.

The Company calculates this higher reserve margin noting that RPM has often resulted in total capacity commitments in excess of reliability targets. But this is merely a result of the sloped RPM capacity demand ("VRR") curve used in the RPM auctions. The sloped VRR curve ensures that when capacity is relatively scarce and costly, RPM's auctions will result in a relatively low amount of committed capacity and high capacity prices; and when capacity is relatively abundant and low cost (as it has been in recent years), RPM will result in a total amount of committed capacity in excess of resource adequacy targets, and relatively low capacity prices. This approach sends a price signal about the need for capacity.

Q 79: Would it be prudent for the Company to plan for the higher reserve margins that often result from the RPM auctions?

A: No, that would not be prudent, and it would make no sense. When RPM results in excess committed capacity, this occurs at a relatively low capacity price, signaling that capacity is abundant and incremental capacity is not needed. Under such circumstances, while the nominal amount of capacity to be allocated to zones and LSEs is higher, the total capacity cost to be allocated is actually much lower. To the extent market participants expect RPM to result in excess capacity at low cost, it would make more sense for market

participants to react to such a situation of abundance by planning relatively less, not more, capacity.

Q 80: Please explain how the total capacity cost is actually lower when RPM clears excess capacity.

A: Consider the following example, using the parameters from the RPM base residual auction for the 2019-2020 delivery year. If RPM cleared at the target reliability requirement, the clearing price would be $434.46/MW-day and the total market cost would be $25 billion. If instead, as actually occurred, RPM clears a large excess at $100/MW-day, the total market cost would be closer to $6 billion (ignoring higher prices in some zones). Thus, when RPM clears excess capacity, it results in less, not more capacity cost allocated to Dominion and other LSEs.

VII. CONCLUSIONS AND RECOMMENDATIONS

Q 81: Please summarize your conclusions with regard to the peak load forecast and Total Resource Requirement values used in the 2018 Plan.

A: I conclude that the Company's DOM Zone peak load values are far too high, and PJM's forecast is also too high, but more accurate than the Company's. In addition, the Company has overstated the DOM LSE's likely portion of that peak in future years. More accurate estimates of DOM Zone and DOM LSE peak loads based on PJM's forecasts, and the resulting TRR values, are shown in Table 1 above.

Q 82: Do you have recommendations with regard to the load forecasts used in future Integrated Resource Plans?

A: Yes. With regard to the peak load forecast, I recommend that the Commission consider requiring the following of the Company, in future plans:

1. To present recent weather-normalized peak loads for the DOM Zone and/or DOM LSE (either prepared by the Company, or by PJM), and to discuss recent trends in weather-normalized peak loads.

2. To commission a forecast of data center loads by an outside firm (as the Company did in 2013 and 2015, resulting in the reports and forecasts prepared by Quanta Technology).

3. To fully separate the forecasting of data center peak loads from the forecasting of all other customer peak loads, and to present the history and forecast of data center and other loads separately. The historical data center loads could be removed from the econometric models used for all other loads, since in any case the Company states that it relies on data center forecasts that it develops applying other methods.

4. To evaluate and report the estimated embedded amount of data center load reflected in the econometric forecasting, and to deduct this embedded amount from the exogenous data center forecast.

5. To provide an explicit forecast of the peak loads of the DOM LSE as a portion of the DOM Zone peak loads, taking into account data centers and any other sectors whose growth differs substantially for DOM LSE and other DOM Zone LSEs, with a discussion of recent trends in DOM LSE and Other LSE peak loads.

6. To present alternative load forecasts determined using 20- and 10-year historical estimation periods, in addition to the longer period currently used, and to provide a discussion of the differences and of the rationale for the choice of historical period.

7. To retain an outside consultant to perform a comprehensive review of the load forecasting methodology and make recommendations for improving accuracy.

Q 83: Do you have recommendations with regard to the calculation of TRRs used in Integrated Resource Plans?

A: Yes. With regard to the calculation of TRRs, I recommend that the Commission consider requiring the Company to use PJM's Forecast Pool Requirement ("FPR") values, applied to a forecast of coincident peak loads, to determine the TRRs in unforced capacity terms, consistent with how PJM allocates capacity cost. The TRRs can also be presented in installed capacity terms, if needed, by applying a DOM LSE fleet-wide average forced outage rate, again consistent with PJM's approach.

Q 84: Does this complete your testimony?

A: Yes it does.

Attachment JFW-1

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SUMMARY

James F. Wilson is an economist with over 30 years of consulting experience, primarily in the electric power and natural gas industries. Many of his assignments have pertained to the economic and policy issues arising from the interplay of competition and regulation in these industries, including restructuring policies, market design, market analysis and market power. Other recent engagements have involved resource adequacy and capacity markets, contract litigation and damages, forecasting and market evaluation, pipeline rate cases and evaluating allegations of market manipulation. Mr. Wilson has been involved in electricity restructuring and wholesale market design for over twenty years in California, PJM, New England, Russia and other regions. He also spent five years in Russia in the early 1990s advising on the reform, restructuring and development of the Russian electricity and natural gas industries.

Mr. Wilson has submitted affidavits and testified in Federal Energy Regulatory Commission and state regulatory proceedings. His papers have appeared in the *Energy Journal*, *Electricity Journal*, *Public Utilities Fortnightly* and other publications, and he often presents at industry conferences.

Prior to founding Wilson Energy Economics, Mr. Wilson was a Principal at LECG, LLC. He has also worked for ICF Resources, Decision Focus Inc., and as an independent consultant.

EDUCATION

MS, Engineering-Economic Systems, Stanford University, 1982

BA, Mathematics, Oberlin College, 1977

RECENT ENGAGEMENTS

- Evaluated the potential impact of an electricity generation operating reserve demand curve on a wholesale electricity market with a capacity construct.
- Developed wholesale capacity market enhancements to accommodate seasonal resources and resource adequacy requirements.
- Evaluation of wholesale electricity market design enhancements to accommodate state initiatives to promote state environmental and other policy objectives.
- Evaluation of proposals for natural gas distribution system expansions.
- Various consulting assignments on wholesale electric capacity market design issues in PJM, New England, the Midwest, Texas, and California.
- Cost-benefit analysis of a new natural gas pipeline.
- Evaluation of the impacts of demand response on electric generation capacity mix and emissions.
- Panelist on a FERC technical conference on capacity markets.
- Affidavit on the potential for market power over natural gas storage.
- Executive briefing on wind integration and linkages to short-term and longer-term resource adequacy approaches.

- Affidavit on the impact of a centralized capacity market on the potential benefits of participation in a Regional Transmission Organization (RTO).
- Participated in a panel teleseminar on resource adequacy policy and modeling.
- Affidavit on opt-out rules for centralized capacity markets.
- Affidavits on minimum offer price rules for RTO centralized capacity markets.
- Evaluated electric utility avoided cost in a tax dispute.
- Advised on pricing approaches for RTO backstop short-term capacity procurement.
- Affidavit evaluating the potential impact on reliability of demand response products limited in the number or duration of calls.
- Evaluated changing patterns of natural gas production and pipeline flows, developed approaches for pipeline tolls and cost recovery.
- Evaluated an electricity peak load forecasting methodology and forecast; evaluated regional transmission needs for resource adequacy.
- Participated on a panel teleseminar on natural gas price forecasting.
- Affidavit evaluating a shortage pricing mechanism and recommending changes.
- Testimony in support of proposed changes to a forward capacity market mechanism.
- Reviewed and critiqued an analysis of the economic impacts of restrictions on oil and gas development.
- Advised on the development of metrics for evaluating the performance of Regional Transmission Organizations and their markets.
- Prepared affidavit on the efficiency benefits of excess capacity sales in readjustment auctions for installed capacity.
- Prepared affidavit on the potential impacts of long lead time and multiple uncertainties on clearing prices in an auction for standard offer electric generation service.

EARLIER PROFESSIONAL EXPERIENCE

LECG, LCC, Washington, DC 1998–2009.
Principal

- Reviewed and commented on an analysis of the target installed capacity reserve margin for the Mid Atlantic region; recommended improvements to the analysis and assumptions.
- Evaluated an electric generating capacity mechanism and the price levels to support adequate capacity; recommended changes to improve efficiency.
- Analyzed and critiqued the methodology and assumptions used in preparation of a long run electricity peak load forecast.
- Evaluated results of an electric generating capacity incentive mechanism and critiqued the mechanism's design; prepared a detailed report. Evaluated the impacts of the mechanism's flaws on prices and costs and prepared testimony in support of a formal complaint.
- Analyzed impacts and potential damages of natural gas migration from a storage field.
- Evaluated allegations of manipulation of natural gas prices and assessed the potential impacts of natural gas trading strategies.
- Prepared affidavit evaluating a pipeline's application for market-based rates for interruptible transportation and the potential for market power.
- Prepared testimony on natural gas industry contracting practices and damages in a contract dispute.
- Prepared affidavits on design issues for an electric generating capacity mechanism for an eastern US regional transmission organization; participated in extensive settlement discussions.
- Prepared testimony on the appropriateness of zonal rates for a natural gas pipeline.
- Evaluated market power issues raised by a possible gas-electric merger.
- Prepared testimony on whether rates for a pipeline extension should be rolled-in or incremental under Federal Energy Regulatory Commission ("FERC") policy.

- Prepared an expert report on damages in a natural gas contract dispute.
- Prepared testimony regarding the incentive impacts of a ratemaking method for natural gas pipelines.
- Prepared testimony evaluating natural gas procurement incentive mechanisms.
- Analyzed the need for and value of additional natural gas storage in the southwestern US.
- Evaluated market issues in the restructured Russian electric power market, including the need to introduce financial transmission rights, and policies for evaluating mergers.
- Affidavit on market conditions in western US natural gas markets and the potential for a new merchant gas storage facility to exercise market power.
- Testimony on the advantages of a system of firm, tradable natural gas transmission and storage rights, and the performance of a market structure based on such policies.
- Testimony on the potential benefits of new independent natural gas storage and policies for providing transmission access to storage users.
- Testimony on the causes of California natural gas price increases during 2000-2001 and the possible exercise of market power to raise natural gas prices at the California border.
- Advised a major US utility with regard to the Federal Energy Regulatory Commission's proposed Standard Market Design and its potential impacts on the company.
- Reviewed and critiqued draft legislation and detailed market rules for reforming the Russian electricity industry, for a major investor in the sector.
- Analyzed the causes of high prices in California wholesale electric markets during 2000 and developed recommendations, including alternatives for price mitigation. Testimony on price mitigation measures.
- Summarized and critiqued wholesale and retail restructuring and competition policies for electric power and natural gas in select US states, for a Pacific Rim government contemplating energy reforms.
- Presented testimony regarding divestiture of hydroelectric generation assets, potential market power issues, and mitigation approaches to the California Public Utilities Commission.
- Reviewed the reasonableness of an electric utility's wholesale power purchases and sales in a restructured power market during a period of high prices.
- Presented an expert report on failure to perform and liquidated damages in a natural gas contract dispute.
- Presented a workshop on Market Monitoring to a group of electric utilities in the process of forming an RTO.
- Authored a report on the screening approaches used by market monitors for assessing exercise of market power, material impacts of conduct, and workable competition.
- Developed recommendations for mitigating locational market power, as part of a package of congestion management reforms.
- Provided analysis in support of a transmission owner involved in a contract dispute with generators providing services related to local grid reliability.
- Authored a report on the role of regional transmission organizations in market monitoring.
- Prepared market power analyses in support of electric generators' applications to FERC for market-based rates for energy and ancillary services.
- Analyzed western electricity markets and the potential market power of a large producer under various asset acquisition or divestiture strategies.
- Testified before a state commission regarding the potential benefits of retail electric competition and issues that must be addressed to implement it.
- Prepared a market power analysis in support of an acquisition of generating capacity in the New England market.
- Advised a California utility regarding reform strategies for the California natural gas industry, addressing market power issues and policy options for providing system balancing services.

ICF RESOURCES, INC., Fairfax, VA, 1997–1998.
Project Manager

- Reviewed, critiqued and submitted testimony on a New Jersey electric utility's restructuring proposal, as part of a management audit for the state regulatory commission.
- Assisted a group of US utilities in developing a proposal to form a regional Independent System Operator (ISO).
- Researched and reported on the emergence of Independent System Operators and their role in reliability, for the Department of Energy.
- Provided analytical support to the Secretary of Energy's Task Force on Electric System Reliability on various topics, including ISOs. Wrote white papers on the potential role of markets in ensuring reliability.
- Recommended near-term strategies for addressing the potential stranded costs of non-utility generator contracts for an eastern utility; analyzed and evaluated the potential benefits of various contract modifications, including buyout and buydown options; designed a reverse auction approach to stimulating competition in the renegotiation process.
- Designed an auction process for divestiture of a Northeastern electric utility's generation assets and entitlements (power purchase agreements).
- Participated in several projects involving analysis of regional power markets and valuation of existing or proposed generation assets.

IRIS MARKET ENVIRONMENT PROJECT, 1994–1996.
Project Director, Moscow, Russia

Established and led a policy analysis group advising the Russian Federal Energy Commission and Ministry of Economy on economic policies for the electric power, natural gas, oil pipeline, telecommunications, and rail transport industries (*the Program on Natural Monopolies,* a project of the IRIS Center of the University of Maryland Department of Economics, funded by USAID):

- Advised on industry reforms and the establishment of federal regulatory institutions.
- Advised the Russian Federal Energy Commission on electricity restructuring, development of a competitive wholesale market for electric power, tariff improvements, and other issues of electric power and natural gas industry reform.
- Developed policy conditions for the IMF's $10 billion Extended Funding Facility.
- Performed industry diagnostic analyses with detailed policy recommendations for electric power (1994), natural gas, rail transport and telecommunications (1995), oil transport (1996).

Independent Consultant stationed in Moscow, Russia, 1991–1996

Projects for the WORLD BANK, 1992-1996:

- Bank Strategy for the Russian Electricity Sector. Developed a policy paper outlining current industry problems and necessary policies, and recommending World Bank strategy.
- Russian Electric Power Industry Restructuring. Participated in work to develop recommendations to the Russian Government on electric power industry restructuring.
- Russian Electric Power Sector Update. Led project to review developments in sector restructuring, regulation, demand, supply, tariffs, and investment.
- Russian Coal Industry Restructuring. Analyzed Russian and export coal markets and developed forecasts of future demand for Russian coal.
- World Bank/IEA Electricity Options Study for the G-7. Analyzed mid- and long-term electric power demand and efficiency prospects and developed forecasts.
- Russian Energy Pricing and Taxation. Developed recommendations for liberalizing energy markets, eliminating subsidies and restructuring tariffs for all energy resources.

Other consulting assignments in Russia, 1991–1994:

- Advised on projects pertaining to Russian energy policy and the transition to a market economy in the energy industries, for the Institute for Energy Research of the Russian Academy of Sciences.
- Presented seminars on the structure, economics, planning, and regulation of the energy and electric power industries in the US, for various Russian clients.

DECISION FOCUS INC., Mountain View, CA, 1983–1992
Senior Associate, 1985-1992.

- For the Electric Power Research Institute, led projects to develop decision-analytic methodologies and models for evaluating long term fuel and electric power contracting and procurement strategies. Applied the methodologies and models in numerous case studies, and presented several workshops and training sessions on the approaches.
- Analyzed long-term and short-term natural gas supply decisions for a large California gas distribution company following gas industry unbundling and restructuring.
- Analyzed long term coal and rail alternatives for a midwest electric utility.
- Evaluated bulk power purchase alternatives and strategies for a New Jersey electric utility.
- Performed a financial and economic analysis of a proposed hydroelectric project.
- For a natural gas pipeline company serving the Northeastern US, forecasted long-term natural gas supply and transportation volumes. Developed a forecasting system for staff use.
- Analyzed potential benefits of diversification of suppliers for a natural gas pipeline company.
- Evaluated uranium contracting strategies for an electric utility.
- Analyzed telecommunications services markets under deregulation, developed and implemented a pricing strategy model. Evaluated potential responses of residential and business customers to changes in the client's and competitors' telecommunications services and prices.
- Analyzed coal contract terms and supplier diversification strategies for an eastern electric utility.
- Analyzed oil and natural gas contracting strategies for an electric utility.

TESTIMONY AND AFFIDAVITS

In the Matter of the Application of Duke Energy Ohio for an Increase in Electric Distribution Rates, etc., Public Utilities Commission of Ohio Case No. 17-32-EL-AIR et al, Direct Testimony on Behalf of the Office of the Ohio Consumers' Counsel, June 25, 2018; deposition, July 3, 2018; testimony at hearings, July 19, 2018.

In the Matter of the Application of DTE Gas Company for Approval of a Gas Cost Recovery Plan, 5-year Forecast and Monthly GCR Factor for the 12 Months ending March 31, 2019, Michigan Public Service Commission Case No. U-18412, Direct Testimony on behalf of Michigan Environmental Council, June 7, 2018.

Constellation Mystic Power, L.L.C., FERC Docket No. ER18-1639-000 (Mystic Cost of Service Agreement), Affidavit in Support of the Comments of New England States Committee on Electricity, June 6, 2018.

New England Power Generators Association, Complainant v. ISO New England Inc. Respondent, FERC Docket No. EL18-154-000 (re: capacity offer price of Mystic power plant), Affidavit in Support of the Protest of New England States Committee on Electricity, June 6, 2018.

PJM Interconnection, L.L.C., FERC Docket No. ER18-1314 (Capacity repricing or MOPR-Ex), Affidavit in Support of the Protests of DC-MD-NJ Consumer Coalition, Joint Consumer Advocates, and Clean Energy Advocates, May 7, 2018; reply affidavit, June 15, 2018.

In the Matter of the Application of DTE Electric Company for Authority to Implement a Power Supply Cost Recovery Plan in its Rate Schedules for 2018 Metered Jurisdictional Sales of Electricity, Michigan Public Service Commission Case No. U-18403, Direct Testimony on behalf of Michigan Environmental Council and Sierra Club, April 20, 2018.

Virginia Electric and Power Company's Integrated Resource Plan filing, Virginia State Corporation Commission Case No. PUE-2017-00051, Direct Testimony on behalf of Environmental Respondents, August 11, 2017; testimony at hearings September 26, 2017.

Ohio House of Representatives Public Utilities Committee hearing on House Bill 178 (Zero Emission Nuclear Resource legislation), Opponent Testimony on Behalf of Natural Resources Defense Council, May 15, 2017.

In the Matter of the Application of Atlantic Coast Pipeline, Federal Energy Regulatory Commission Docket No. CP15-554, Evaluating Market Need for the Atlantic Coast Pipeline, Attachment 2 to the comments of Shenandoah Valley Network *et al*, April 6, 2017.

In the Matter of the Application of DTE Electric Company for Authority to Implement a Power Supply Cost Recovery Plan in its Rate Schedules for 2017 Metered Jurisdictional Sales of Electricity, Michigan Public Service Commission Case No. U-18143, Direct Testimony on behalf of Michigan Environmental Council and Sierra Club, March 22, 2017.

In the Matter of the Petition of Washington Gas Light Company for Approval of Revised Tariff Provisions to Facilitate Access to Natural Gas in the Company's Maryland Franchise Area That Are Currently Without Natural Gas Service, Maryland Public Service Commission Case No. 9433, Direct Testimony on Behalf of the Mid-Atlantic Propane Gas Association and the Mid-Atlantic Petroleum Distributors Association, Inc., March 1, 2017; testimony at hearings, May 1, 2017.

In the Matter of Integrated Resource Plans and Related 2016 REPS Compliance Plans, North Carolina Utilities Commission Docket No. E-11 Sub 147, Review and Evaluation of the Peak Load Forecasts and Reserve Margin Determinations for the Duke Energy Carolinas and Duke Energy Progress 2016 Integrated Resource Plans, Attachments A and B to the comments of the Natural Resources Defense Council, Southern Alliance for Clean Energy, and the Sierra Club, February 17, 2017.

In the Matter of the Tariff Revisions Designated TA285-4 filed by ENSTAR Natural Gas Company, a Division of SEMCO Energy, Inc., Regulatory Commission of Alaska Case No. U-16-066, Testimony on Behalf of Matanuska Electric Association, Inc., February 7, 2017, testimony at hearings, June 21, 2017.

PJM Interconnection, L.L.C., FERC Docket No. ER17-367 (seasonal capacity), Prepared Testimony on Behalf of Advanced Energy Management Alliance, Environmental Law & Policy Center, Natural Resources Defense Council, Rockland Electric Company and Sierra Club, December 8, 2016; Declaration in support of Protest of Response to Deficiency Letter, February 13, 2017.

Natural Resources Defense Council, Sierra Club, and Union of Concerned Scientists v. Federal Energy Regulatory Commission, U.S. District Court of Appeals for the D.C. Circuit Case No. 16-1236 (Capacity Performance), Declaration, September 23, 2016.

Mountaineer Gas Company Infrastructure Replacement and Expansion Program Filing for 2016, West Virginia Public Service Commission Case No. 15-1256-G-390P, and Mountaineer Gas Company Infrastructure Replacement and Expansion Program Filing for 2017, West Virginia Public Service Commission Case No. 16-0922-G-390P, Direct Testimony on behalf of the West Virginia Propane Gas Association, September 9, 2016.

Application of Chesapeake Utilities Corporation for a General Increase in its Natural Gas Rates and for Approval of Certain Other Changes to its Natural Gas Tariff, Delaware P.S.C. Docket No. 15-1734, Direct Testimony on behalf of the Delaware Association Of Alternative Energy Providers, Inc., August 24, 2016.

Virginia Electric and Power Company's Integrated Resource Plan filing, Virginia State Corporation Commission Case No. PUE-2016-00049, Direct Testimony on behalf of Environmental Respondents, August 17, 2016; testimony at hearings October 5, 2016.

In the Matter of the Application of DTE Electric Company for Authority to Implement a Power Supply Cost Recovery Plan in its Rate Schedules for 2016 Metered Jurisdictional Sales of Electricity, Michigan Public Service Commission Case No. U-17920, Direct Testimony on behalf of Michigan Environmental Council and Sierra Club, March 14, 2016.

In the Matter of the Application Seeking Approval of Ohio Power Company's Proposal to Enter into an Affiliate Power Purchase Agreement for Inclusion in the Power Purchase Agreement Rider, Public Utilities Commission of Ohio Case No. 14-1693-EL-RDR: Direct Testimony on Behalf of the Office of the Ohio Consumers' Counsel, September 11, 2015; deposition, September 30, 2015; supplemental deposition, October 16, 2015; testimony at hearings, October 21, 2015; supplemental testimony December 28, 2015; second supplemental deposition, December 30, 2015; testimony at hearings January 8, 2016.

Indicated Market Participants v. PJM Interconnection, L.L.C., FERC Docket No. EL15-88 (Capacity Performance transition auctions), Affidavit on behalf of the Joint Consumer Representatives and Interested State Commissions, August 17, 2015.

ISO New England Inc. and New England Power Pool Participants Committee, FERC Docket No. ER15-2208 (Winter Reliability Program), Testimony on Behalf of the New England States Committee on Electricity, August 5, 2015.

Joint Consumer Representatives v. PJM Interconnection, L.L.C., FERC Docket No. EL15-83 (load forecast for capacity auctions), Affidavit in Support of the Motion to Intervene and Comments of the Public Power Association of New Jersey, July 20, 2015.

In the Matter of the Tariff Revisions Filed by ENSTAR Natural Gas Company, a Division of SEMCO Energy, Inc., Regulatory Commission of Alaska Case No. U-14-111, Testimony on Behalf of Matanuska Electric Association, Inc., May 13, 2015.

In the Matter of the Application of Ohio Edison Company et al for Authority to Provide for a Standard Service Offer Pursuant to R.C. 4928.143 in the Form of an Electric Security Plan, Public Utilities Commission of Ohio Case No. 14-1297-EL-SSO: Direct Testimony on Behalf of the Office of the Ohio Consumers' Counsel and Northeast Ohio Public Energy Council, December 22, 2014; deposition, February 10, 2015; supplemental testimony May 11, 2015; second deposition May 26, 2015; testimony at hearings, October 2, 2015; second supplemental testimony December 30, 2015; third deposition January 8, 2016; testimony at hearings January 19, 2016; rehearing direct testimony June 22, 2016; fourth deposition July 5, 2016; testimony at hearings July 14, 2016.

PJM Interconnection, L.L.C., FERC Docket No. ER14-2940 (RPM Triennial Review), Affidavit in Support of the Protest of the PJM Load Group, October 16, 2014.

In the Matter of the Application of Duke Energy Ohio for Authority to Establish a Standard Service Offer in the Form of an Electric Security Plan, Public Utilities Commission of Ohio Case No. 14-841-EL-SSO: Direct Testimony on Behalf of the Office of the Ohio Consumers' Counsel, September 26, 2014; deposition, October 6, 2014; testimony at hearings, November 5, 2014.

In the Matter of the Application of Ohio Power Company for Authority to Establish a Standard Service Offer in the Form of an Electric Security Plan, Public Utilities Commission of Ohio Case No. 13-2385-EL-SSO: Direct Testimony on Behalf of the Office of the Ohio Consumers' Counsel, May 6, 2014; deposition, May 29, 2014; testimony at hearings, June 16, 2014.

PJM Interconnection, L.L.C., FERC Docket No. ER14-504 (clearing of Demand Response in RPM), Affidavit in Support of the Protest of the Joint Consumer Advocates and Public Interest Organizations, December 20, 2013.

New England Power Generators Association, Inc. v. ISO New England Inc., FERC Docket No. EL14-7 (administrative capacity pricing), Testimony in Support of the Protest of the New England States Committee on Electricity, November 27, 2013.

Midwest Independent Transmission System Operator, Inc., FERC Docket No. ER11-4081 (minimum offer price rule), Affidavit In Support of Brief of the Midwest TDUs, October 11, 2013.

ANR Storage Company, FERC Docket No. RP12-479 (storage market-based rates), Prepared Answering Testimony on behalf of the Joint Intervenor Group, April 2, 2013; Prepared Cross-answering Testimony, May 15, 2013; testimony at hearings, September 4, 2013.

In the Matter of the Application of The Dayton Power and Light Company for Approval of its Market Rate Offer, Public Utilities Commission of Ohio Case No. 12-426-EL-SSO: Direct Testimony on Behalf of the Office of the Ohio Consumers' Counsel, March 5, 2013; deposition, March 11, 2013.

PJM Interconnection, L.L.C., FERC Docket No. ER13-535 (minimum offer price rule), Affidavit in Support of the Protest and Comments of the Joint Consumer Advocates, December 28, 2012.

In the Matter of the Application of Ohio Edison Company, et al for Authority to Provide for a Standard Service Offer in the Form of an Electric Security Plan, Public Utilities Commission of Ohio Case No. 12-1230-EL-SSO: Direct Testimony on Behalf of the Office of the Ohio Consumers' Counsel, May 21, 2012; deposition, May 30, 2012; testimony at hearings, June 5, 2012.

PJM Interconnection, L.L.C., FERC Docket No. ER12-513 (changes to RPM), Affidavit in Support of Protest of the Joint Consumer Advocates and Demand Response Supporters, December 22, 2011.

People of the State of Illinois *ex rel.* Leon A. Greenblatt, III v Commonwealth Edison Company, Circuit Court of Cook County, Illinois, deposition, September 22, 2011; interrogatory, Feb. 22, 2011.

In the Matter of the Application of Union Electric Company for Authority to Continue the Transfer of Functional Control of Its Transmission System to the Midwest Independent Transmission System Operator, Inc., Missouri PSC Case No. EO-2011-0128, Testimony in hearings, February 9, 2012; Rebuttal Testimony and Response to Commission Questions On Behalf Of The Missouri Joint Municipal Electric Utility Commission, September 14, 2011.

PJM Interconnection, L.L.C., and PJM Power Providers Group v. PJM Interconnection, L.L.C., FERC Docket Nos. ER11-2875 and EL11-20 (minimum offer price rule), Affidavit in Support of Protest of New Jersey Division of Rate Counsel, March 4, 2011, and Affidavit in Support of Request for Rehearing and for Expedited Consideration of New Jersey Division of Rate Counsel, May 12, 2011.

PJM Interconnection, L.L.C., FERC Docket No. ER11-2288 (demand response "saturation"), Affidavit in Support of Protest and Comments of the Joint Consumer Advocates, December 23, 2010.

North American Electric Reliability Corporation, FERC Docket No. RM10-10, Comments on Proposed Reliability Standard BAL-502-RFC-02: Planning Resource Adequacy Analysis, Assessment and Documentation, December 23, 2010.

In the Matter of the Reliability Pricing Model and the 2013/2014 Delivery Year Base Residual Auction Results, Maryland Public Service Commission Administrative Docket PC 22, Comments and Responses to Questions On Behalf of Southern Maryland Electric Cooperative, October 15, 2010.

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PROFESSIONAL ASSOCIATIONS

United States Association for Energy Economics

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